X-Pedition™ Security Router

XSR User's Guide
Version 7.6

P/N 9033837-09

enterasys™
Networks that Know

Electrical Hazard: Only qualified personnel should perform installation procedures.

Riesgo Electrico: Solamente personal calificado debe realizar procedimientos de instalacion.

Elektrischer Gefahrenhinweis: Installationen sollten nur durch ausgebildetes und qualifiziertes Personal vorgenommen werden.

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50 Minuteman Road
Andover, MA 01810

Part Number: 9033837-09 September 2005

Documentation URL: http://www.enterasys.com/support/manuals

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Regulatory Compliance Information

Federal Communications Commission (FCC) Notice

The XSR complies with Title 47, Part 15, Class A of FCC rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

NOTE: The XSR has been tested and found to comply with the limits for a class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the XSR is operated in a commercial environment. This XSR uses, generates, and can radiate radio frequency energy and if not installed in accordance with the operator's manual, may cause harmful interference to radio communications. Operation of the XSR in a residential area is likely to cause interference in which case you will be required to correct the interference at your own expense.

WARNING: Modifications or changes made to the XSR, and not approved by Enterasys Networks may void the authority granted by the FCC or other such agency to operate the XSR.

The XSR complies with Part 68 of the FCC rules and the requirements adopted by the Administrative Council for Terminal Attachments (ACTA). A label on the circuit board of the Network Interface Module contains, among other information, a product identifier in the format listed in the following table. If requested, this number must be provided to the telephone company.

Product	Product Identifier
NIM-T1/E1-xx, NIM-CT1E1/PRI-xx	US: 5N5DENANET1
NIM-BRI-U-xx	US: 5N5DENANEBU
NIM-ADSL-AC-xx	US: 5N5DL02NEAA
NIM-DIRELAY-xx	US: 5N5DENANEDI
NIM-TE1-xx, NIM-CTE1-PRI-xx	US: 5N5DENANECT

A plug and jack used to connect the XSR to the premises wiring and telephone network must comply with the applicable FCC Part 68 rules and requirements adopted by ACTA. Refer to the following table and installation instructions for details.

Product	Jack Used
NIM-T1/E1-xx, NIM-CT1E1/PRI-xx, NIM-DIRELAY-xx, NIM-TE1-xx, NIM-CTE1-PRI-xx	RJ48C
NIM-BRI-U-xx	RJ49C
NIM-ADSL-AC-xx	RJ11C

Codes applicable to this equipment:

Product	Facilities Interface Code (FIC)	Service Order Code (SOC)
NIM-T1/E1-xx, NIM-CT1E1/PRI-xx, NIM-DIRELAY-xx, NIM-TE1-xx, NIM-CTE1-PRI-xx	04DU9.BN, 04DU9.DN, 04DU9.1KN, 04DU9.1SN	6.0N
NIM-BRI-U-xx	02IS5	6.0N
NIM-ADSL-AC-xx	02LS2	7.0Y

If the XSR harms the telephone network, the telephone company will notify you in advance that it may need to temporarily discontinue service. But if advance notice is not practical, the telephone company will notify you as soon as possible. Also, you will be advised of your right to file a complaint with the FCC if you believe it is necessary.

The telephone company may make changes in its facilities, equipment, operations, or procedures that could affect the operation of the XSR. If this happens, the telephone company will provide advance notice for you to make necessary modifications and maintain uninterrupted service.

If you experience trouble with the XSR, for repair or warranty information, please contact Enterasys Networks, Inc., at 978-684-1000. If the XSR is causing harm to the telephone network, the telephone company may request that you disconnect the equipment until the problem is solved. The XSR is not intended to be repaired by the customer.

Industry Canada Notices

This digital apparatus does not exceed the class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de la class A prescrites dans le Règlement sur le brouillage radioélectrique édicté par le ministère des Communications du Canada.

Equipment Attachments Limitations

"NOTICE: The Industry Canada label identifies certified equipment. This certification means that the equipment meets telecommunications network protective, operational and safety requirements as prescribed in the appropriate Terminal Equipment Technical Requirements document(s). The department does not guarantee the equipment will operate to the user's satisfaction.

Before installing this equipment, users should ensure that it is permissible to be connected to the facilities of the local telecommunications company. The equipment must also be installed using an acceptable method of connection. The customer should be aware that compliance with the above conditions may not prevent degradation of service in some situations.

Repairs to certified equipment should be coordinated by a representative designated by the supplier. Any repairs or alterations made by the user to this equipment, or equipment malfunctions, may give the telecommunications company cause to request the user to disconnect the equipment.

Users should ensure for their own protection that the electrical ground connections of the power utility, telephone lines and internal metallic water pipe system, if present, are connected together. This precaution may be particularly important in rural areas. Caution: Users should not attempt to make such connections themselves, but should contact the appropriate electric inspection authority, or electrician, as appropriate."

"NOTICE: The Ringer Equivalence Number (REN) assigned to each terminal device provides an indication of the maximum number of terminals allowed to be connected to a telephone interface. The termination on an interface may consist of any combination of devices subject only to the requirement that the sum of the ringer equivalence Numbers of all the devices does not exceed 5."

R & TTE Directive Declaration

Hereby, Enterasys Networks, Inc. declares that this XSR-1850 X-Pedition Security Router is compliant with essential requirements and other relevant provisions of Directive 1999/5/EC.

Class A ITE Notice

WARNING: This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

Clase A. Aviso de ITE

ADVERTENCIA: Este es un producto de Clase A. En un ambiente doméstico este producto puede causar interferencia de radio en cuyo caso puede ser requerido tomar medidas adecuadas.

Klasse A ITE Anmerkung

WARNHINWEIS: Dieses Produkt zählt zur Klasse A (Industriebereich). In Wohnbereichen kann es hierdurch zu Funkstörungen kommen, daher sollten angemessene Vorkehrungen zum Schutz getroffen werden.

Product Safety

This product complies with the following: UL 60950, CSA C22.2 No. 60950, 73/23/EEC, EN 60950, EN 60825, IEC 60950.

Use the XSR with the Advanced Power Solutions (APS61ES-30) power supply included with the branch router. Enterasys Networks strongly recommends that you use only the proper type of power supply cord set for the XSR. It should be a detachable type, UL listed/CSA certified, type SJ or SJT, rated 250 V minimum, 7 amp with grounding-type attachment plug. Maximum length is 15 feet (4.5 meters). The cord set should have the appropriate safety approval for the country in which the equipment will be installed.

Seguridad del Producto

El producto de Enterasys cumple con lo siguiente: UL 60950, CSA C22.2 No. 60950, 73/23/EEC, EN 60950, EN 60825, IEC 60950.

Produktsicherheit

Dieses Produkt entspricht den folgenden Richtlinien: UL 60950, CSA C22.2 No. 60950, 73/23/EEC, EN 60950, EN 60825, IEC 60950.

Electromagnetic Compatibility (EMC)

This product complies with the following: 47 CFR Parts 2 and 15, CSA C108.8, 89/336/EEC, EN 55022, EN 55024, EN 61000-3-2, EN 61000-3-3, AS/NZS CISPR 22, and VCCI V-3.

Compatibilidad Electromágnetica (EMC)

Este producto de Enterasys cumple con lo siguiente: 47 CFR Partes 2 y 15, CSA C108.8, 89/336/EEC, EN 55022, EN 55024, EN 61000-3-2, EN 61000-3-3, AS/NZS CISPR 22, VCCI V-3.

Elektro- magnetische Kompatibilität (EMC)

Dieses Produkt entspricht den folgenden Richtlinien: 47 CFR Parts 2 and 15, CSA C108.8, 89/336/EEC, EN 55022, EN 55024, EN 61000-3-2, EN 61000-3-3, AS/NZS CISPR 22, VCCI V-3.

European Waste Electrical and Electronic Equipment (WEEE) Notice

In accordance with Directive 2002/96/EC of the European Parliament on waste electrical and electronic equipment (WEEE):

1. The symbol above indicates that separate collection of electrical and electronic equipment is required and that this product was placed on the European market after August 13, 2005, the date of enforcement for Directive 2002/96/EC.
2. When this product has reached the end of its serviceable life, it cannot be disposed of as unsorted municipal waste. It must be collected and treated separately.
3. It has been determined by the European Parliament that there are potential negative effects on the environment and human health as a result of the presence of hazardous substances in electrical and electronic equipment.
4. It is the users' responsibility to utilize the available collection system to ensure WEEE is properly treated.

   For information about the available collection system, please go to http://www.enterasys.com/support/ or contact Enterasys Customer Support at 353 61 705586 (Ireland).

VCCI Notice

This is a class A product based on the standard of the Voluntary Control Council for Interference by Information Technology Equipment (VCCI) V-3. If this equipment is used in a domestic environment, radio disturbance may arise. When such trouble occurs, the user may be required to take corrective actions.

この装置は，情報処理装置等電波障害自主規制協議会（ＶＣＣＩ）の基準に基づくクラスＡ情報技術装置です。この装置を家庭環境で使用すると電波妨害を引き起こすことがあります。この場合には使用者が適切な対策を講ずるよう要求されることがあります。

BSMI EMC Statement — Taiwan

This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

警告使用者：

這是甲類的資訊產品，在居住的環境中使用時，可能會造成射頻干擾，在這種請況下，使用者會被要求採取某些適當的對策。

Declaration of Conformity

Application of Council Directive(s):	**89/336/EEC** **73/23/EEC**
Manufacturer's Name:	**Enterasys Networks, Inc.**
Manufacturer's Address:	**50 Minuteman Road** **Andover, MA 01810** **USA**
European Representative Address:	**Enterasys Networks, Ltd.** **Nexus House, Newbury Business Park** **London Road, Newbury** **Berkshire RG14 2PZ, England**
Conformance to Directive(s)/Product Standards:	**EC Directive 89/336/EEC** **EN 55022** **EN 61000-3-2** **EN 61000-3-3** **EN 55024** **EC Directive 73/23/EEC** **EN 60950** **EN 60825**
Equipment Type/Environment:	**Networking Equipment, for use in a Commercial or Light Industrial Environment.**

Enterasys Networks, Inc. declares that the equipment packaged with this notice conforms to the above directives.

Australian Telecom

N826

WARNING: Do not install phone line connections during an electrical storm.

WARNING: Do not connect phone line until the interface has been configured through local management. The service provider may shut off service if an un-configured interface is connected to the phone lines.

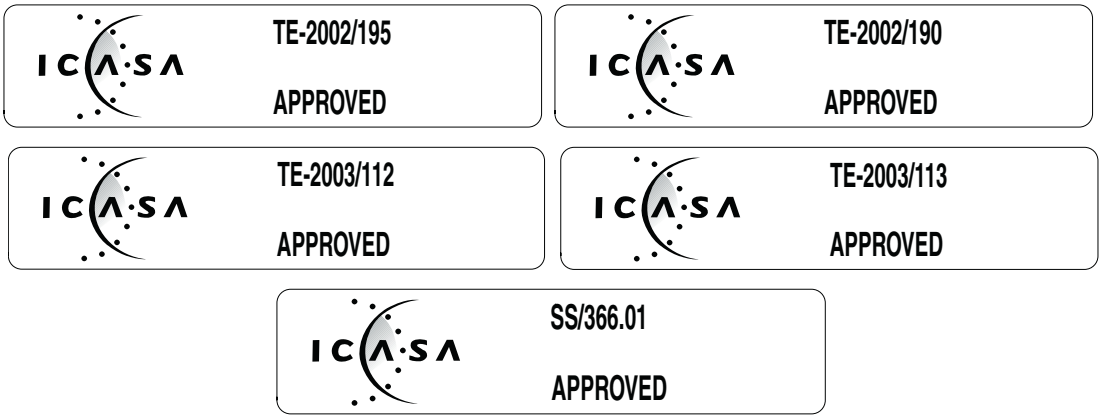
WARNING: The NIM-BRI-ST cannot be connected directly to outside lines. An approved channel service unit (CSU) must be used for connection to the ISDN network. In some areas this CSU is supplied by the network provider and in others it must be supplied by the user. Contact your service provider for details.

Federal Information Processing Standard (FIPS) Certification

The XSR has been submitted to the National Institute of Standards and Technology (NIST) for FIPS 140-2 certification and is now officially listed on the NIST pre-validation list. For more information about the FIPS validation program, go to http://csrc.nist.gov/cryptval/preval.htm. For the FIPS 140-1 and 140-2 Pre-Validation List, click on the **[PDF]** link at the top of the page.

Independent Communications Authority of South Africa

This product complies with the terms of the provisions of section 54(1) of the Telecommunications Act (Act 103 of 1996) and the Telecommunications Regulation prescribed under the Post Office Act (Act 44 of 1958).



VPN Consortium Interoperability

The VPN Consortium's (VPNC) testing program is an important source for certification of conformance to IPSec standards. With rigorous interoperability testing, the VPNC logo program provides IPSec users even more assurance that the XSR will interoperate in typical business environments. VPNC is the only major IPSec testing organization that shows both proof of interoperability as well as the steps taken so that you can reproduce the tests.

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Preface

This guide provides a general overview of the XSR hardware and software features. It describes how to configure and maintain the router. Refer to the *XSR CLI Reference Guide* and the *XSR Getting Started Guide* for information not contained in this document.

This guide is written for administrators who want to configure the XSR or experienced users who are knowledgeable of basic networking principles.

Contents of the Guide

Information in this guide is arranged as follows:

- *Chapter 1, Overview,* introduces key features of the XSR.
- *Chapter 2, Managing the XSR*, describes the three methods of managing the router along with the control commands and tools available to accomplish that task including Remote Auto Install (RAI) and memory management.
- *Chapter 3, Managing LAN/WAN Interfaces*, describes system FastEthernet/GigabitEthernet and High Speed Serial features, how to configure them, and MIB-II statistics collected for LAN interfaces.
- *Chapter 4, Configuring T1/E1 & T3/E3 Interfaces*, outlines XSR controller features, including the Drop and Insert NIM, and how to configure and troubleshoot them.
- *Chapter 5, Configuring IP,* outlines a host of XSR IP protocol suite features, including Secondary IP, VRRP, Proxy DNS, VLAN and Policy Based routing, Route Preference, multiple static routes, CIDR, and their associated configuration.
- *Chapter 6, Configuring the Border Gateway Protocol*, describes XSR-supported BGP-4 features including MIB tables defined in RFC-1657, BGP SNMP traps, protection of sessions, capabilities advertisement, route reflection, communities, route refresh, route flap dampening, AS confederations, and debug capability.
- *Chapter 7, Configuring PIM-SM and IGMP*, describes Protocol Independent Multicast - Sparse Mode (PIM-SM) and Internet Group Management Protocol (IGMP) configuration with these features and how to configure them: IGMP versions 1, 2 and 3 (on LAN interface only), PIM-SM version 2, Static IGMP group membership, Dynamic and Static RP, Register and Assert Mechanism, Rendezvous Point Tree (RPT) Build-up, Shortest Path Tree (SPT) Build-up, RPT to SPT Switch, Join/Prune Mechanism, and Source Specific Multicast (SSM) Support.
- *Chapter 8, Configuring PPP,* details XSR support for the PPP and Multi-link PPP protocols, Multi-Class MLPPP, peer entity authentication, Bandwidth on Command (BAP), and how to configure these features.
- *Chapter 9, Configuring Frame Relay*, details how to set up Frame Relay networks on the XSR, including using rate enforcement (CIR) and congestion control (FECN and BECN), Discard Eligibility, Frame Relay Inverse ARP, LMI support, and FRF.12 fragmentation.
- *Chapter 10, Configuring Dial Services and Back Up,* details background information about Dial Services and Dial Backup across a PSTN, Ethernet failover, Dial on Demand (DoD) and Bandwidth on Demand (BoD), Multi-link PPP, dialer interface spoofing, Dialer Watch, ISDN callback, and the commands to configure these features.

- *Chapter 11, Configuring ISDN,* outlines how to set up the Integrated Services Digital Network protocol on the XSR for BRI, PRI and leased line applications. ISDN protocol tracing and partial decoding of Q921 and Q931 frames is also described.
- *Chapter 12, Configuring Quality of Service*, describes XSR support for QoS, including Random Early Detection (RED), Weighted Random Early Detection (WRED), tail-drop, DSCP, IP precedence, traffic policing and shaping, priority and CBWFQ queuing, and class-based traffic shaping.
- *Chapter 13, Configuring ADSL,* details ADSL line operation over POTS and ISDN circuits, ADSL data framing format ATM Frame UNI, OAM cell behavior, PDU encapsulation choices: PPP over ATM (PPPoA), PPP over Ethernet (PPPoE), and Routed IP over ATM (IPoA).
- *Chapter 14, Configuring the Virtual Private Network,* outlines XSR support for Site-to-Site, Site-to-Central-Site, and Remote Access VPN applications. Other supported functionality includes RADIUS authentication, PKI authentication, NAT traversal, IP address management, dynamic routing over VPN (remote access only), digital signature and certificate support, GRE over IPSec, and AAA.
- *Chapter 15, Configuring DHCP,* details the router's support for the Dynamic Host Configuration Protocol including dynamic and manual IP address allocation, persistent storage of client values, temporary or permanent network address allocation, and nested scopes.
- *Chapter 16, Configuring Security on the XSR*, describes methods to protect the router against hacker attacks and install strong security including ACLs, AAA service, firewall, and how to configure these features.
- *Appendix A, Alarms/Events and System Limits,* lists the high, medium and low severity alarms and events captured by the XSR as well as system limits for various XSR functions as a function of installed memory.
- *Appendix B, SNMP Proprietary and Associated Standard MIBs*, lists and describes XSR-supported SNMP tables and objects for the following standard (partial listing) and proprietary MIBS.

Conventions Used in This Guide

The following conventions are used in this guide

Note: Calls the reader's attention to any item of information that may be of special importance.

Nota: Llama la atencion del lector a cierta información que puede ser de especial importancia.

Caution: Contains information essential to avoid damage to the equipment.

Precaución: Contiene información esencial para prevenir dañar el equipo.

Achtung: Verweißt auf wichtige Informationen zum Schutz gegen Beschädigungen.

Electrical Hazard: Warns against an action that could result in personal injury or death due to an electrical hazard.

Riesgo Electrico: Advierte contra una acción que pudiera resultar en lesión corporal o la muerte debido a un riesgo eléctrico.

Elektrischer Gefahrenhinweis: Installationen sollten nur durch ausgebildetes und qualifiziertes. Personal vorgenommen werden.

Warning: Warns against an action that could result in personal injury or death.

Advertencia: Advierte contra una acción que pudiera resultar en lesión corporal o la muerte.

Warnhinweis: Warnung vor Handlungen, die zu Verletzung von Personen oder gar Todesfällen führen können!

Bold/En negrilla	Text in boldface indicates values you type using the keyboard or select using the mouse (for example, a:\setup). Default settings may also appear in bold. El texto en negrilla indica valores que usted introduce con el teclado o que selecciona con el mouse (por ejemplo, a:\setup). Las configuraciones default pueden también aparecer en en negrilla.
Italics/It áli ca	Text in italics indicates a variable, important new term, or the title of a manual. El texto en itálica indica un valor variable, un importante nuevo término, o el título de un manual.
SMALL CAPS/ MAYUSCULAS	Small caps specify the keys to press on the keyboard; a plus sign (+) between keys indicates that you must press the keys simultaneously (for example, CTRL+ALT+DEL). Las mayusculas indican las teclas a oprimir en el teclado; un signo de más (+) entre las teclas indica que usted debe presionar las teclas simultáneamente (por ejemplo, CTRL+ALT+DEL).
Courier font/ Tipo de letra Courier	Text in this font denotes a file name or directory. El texto en este tipo de letra denota un nombre de archivo o de directorio.
+	Points to text describing CLI command. Apunta al texto que describe un comando de CLI.
FastEthernet	FastEthernet and GigabitEthernet references are generally interchangeable throughout this guide. Las referencias a los terminos FastEthernet y GigabitEthernet son generalmente intercambiables en el contenido de esta guia.

Getting Help

For additional support related to the XSR, contact Enterasys Networks by one of these methods:

World Wide Web	http://www.enterasys.com
Phone	(978) 684-1000 1-800-872-8440 (toll-free in U.S. and Canada) For the Enterasys Networks Support toll-free number in your country: http://www.enterasys.com/support/gtac-all.html
Internet mail	support@enterasys.com To expedite your message, please type **[xsr]** in the subject line.
FTP	ftp://ftp.enterasys.com
Login	anonymous
Password	your email address
Acquire the latest image and Release Notes	http://www.enterasys.com/download
Additional documentation	http://www.enterasys.com/support/manuals
Forward comments or suggestions	techpubs@enterasys.com To expedite your message, include the document Part Number in the subject of your email.

Before contacting Enterasys Networks for technical support, have the following information ready:

- Your Enterasys Networks service contract number
- A description of the failure
- A description of any action(s) already taken to resolve the problem (e.g., rebooting the unit, reconfiguring modules, etc.)
- The serial and revision numbers of all relevant Enterasys Networks products in the network
- A description of your network environment (layout, cable type, etc.)
- Network load and frame size at the time of the problem
- The XSR's history (i.e., have you returned the device before, is this a recurring problem, etc.)
- Any previous Return Material Authorization (RMA) numbers

1

Overview

This chapter briefly describes the functionality of the XSR. Refer to the following chapters in this manual for details on how to configure this functionality and the *XSR CLI Reference Guide* for a description of associated CLI commands and examples.

The following functionality is supported on the XSR:

- *System Management* - The XSR's resources can be managed via four methods: the Command Line Interface (CLI) for full configuration, performance and fault management; the Simple Network Management Protocol including SNMP v1/v2c/v3 agent, for remote monitoring; the NetSight Atlas Router Services Manager application for firewall and ACL configuration; and the Web to gather version information. These tools control the XSR's many hardware and software facilities. Also supported: memory management, SSH v2 server, full configuration backup and restore, EOS Fallback for reliable image upgrades, Simple Network Time Protocol (SNTP v3) client and server (unicast mode) external source synchronization, login banner, and a host of proprietary and standard MIBs including Download, Syslog, Configuration Management, Configuration Change, Timed Reset, Chassis, Persistence, Host Resource, Enterprise Firewall and VPN, and Protocol MIBs (OSPF, RIP, Frame Relay, and PPP), SNMP Informs and Service Level Agreement (SLA) agents. The XSR's SNMP MIBs support readable checksums on XSR configurations and the *Enterasys Configuration Management MIB* will TFTP a file on-the-fly to the XSR Flash, load the file to *running config* and save it to *startup-config*. The XSR also supports placing a hostname in the Syslog message header and configuring multiple Syslog servers.
- *Remote Auto Install* (RAI) - automatically retrieves a centrally managed configuration specifically created for a remote XSR by one of three methods: over a Frame Relay network using the lowest numbered serial port, a PPP connection using the lowest numbered serial port, or over an ADSL connection.
- *Ethernet Interfaces* - The XSR 1800 Series' two 10/100 Base-T FastEthernet interfaces and XSR 3000 Series' three 10/100/1000 BaseT GigabitEthernet interfaces handle the router's LAN traffic stream, with support for alarms and events, diagnostics, packet filtering and statistics gathering, and Ethernet backup.
- *T1/E1 & T3/E3 Interfaces* - The XSR's T1/E1 and T3/E3 subsystem on NIM-based I/O cards handle the router's WAN traffic with support for alarm detection and signaling, diagnostics, line encoding, the Drop & Insert NIM, and a host of other functionality.
- *Serial Interface* - The XSR's NIM serial interface typically supports PPP providing both asynchronous and synchronous protocol support. The XSR's Console port can also be used as a Serial connection to the router for remote or backup dialin.
- *PPP* (WAN) -The Point-to-Point Protocol (PPP) provides a standard method for transporting multi-protocol datagrams over point-to-point links. PPP defines procedures for the assignment and management of network addresses, asynchronous and synchronous encapsulation, link configuration, link quality testing, network protocol multiplexing, error detection, and option negotiation for such capabilities as network-layer address negotiation

and data-compression negotiation. Also supported: PPPoE client and sub-interface monitoring, and Multilink PPP protocols as well as Dial on Demand (DoD), Bandwidth on Demand (BoD), Multi-Class MLPPP.

- *IP Protocol* - IP supports interconnected systems of packet-switched computer communication networks. It uses a 32-bit addressing scheme where an IP address is represented by four fields, each containing 8-bit numbers. Also supported: secondary IP addressing, CIDR, the Virtual Router Redundancy Protocol (VRRP), Proxy DNS, VLAN and Policy Based routing, Route Preference, multiple static routes, and AAA, PPP and OSPF debugging.
- *DHCP* - The XSR supports DHCP Server and Client on the trusted LAN to provide IP addresses to computers on a customer's private LAN segment, temporary or permanent network (IP) address and network configuration parameter assignment to clients, persistent storage/database of network values for network clients - Bindings Database, persistent storage of network client lease states kept after a system reboot, persistent and user-controllable conflict avoidance to prevent duplicate IP address including configurable ping checking, and visibility of DHCP network activity and leases through operator reports statistics and logs.
- *Network Address Translation* - static NAT, Network Address Port Translation (NAPT) and dynamic NAT by source/destination IP address, dynamic NAT pool mapping with overload, PPTP/GRE ALG and arbitrary IP address for NAPT, on the interface and port-forwarded static NAT, multiple NATs on an interface.
- *IP Routing* - The XSR supports RIP, OSPF and BGP4 dynamic routing, a vital function of the IP protocol. Stored in a routing table, network data is used to determine the route for each packet passing through the XSR. Also supported: route redistribution between OSPF and RIP, static routes, multiple static routes to the same destination with different hops and distances, Virtual Router Redundancy Protocol (VRRP) for default router redundancy and load balancing, DNS proxy, Virtual Area Networks (VLAN 802.1Q), priority VLAN routing 802.1P, policy based routing, route preference, multiple static routes, Protocol Independent Multicast - Sparse Mode (PIM-SM), and configurable RIP and OSPF poll timers.
- *Equal-Cost Multi-Path* (ECMP) - per packet and per flow (round robin) support for OSPF, BGP and static routes (RIP excluded).
- *Border Gateway Protocol v4* - The XSR supports the following the BGP-4 features: all MIB tables defined in RFC-1657 including BGP SNMP traps, protection of BGP sessions, capabilities advertisement, route reflection, communities, route refresh, route flap dampening, AS confederations, debugging, per neighbor configurable BGP timer and filter tags.
- *PIM/IGMP* - Protocol Independent Multicast - Sparse Mode (PIM-SM) and Internet Group Management Protocol (IGMP) is supported with the following features: IGMP versions 1, 2 and 3 (on LAN interface only), PIM-SM version 2, static IGMP group membership, dynamic RP (BootStrap without Admin Scope Zone support), static RP, register and assert mechanism, Rendezvous Point Tree (RPT) and Shortest Path Tree (SPT) Build-up, RPT to SPT Switch, Join/Prune Mechanism, and Source Specific Multicast (SSM).
- *Frame Relay* - The XSR provides this fast-packet switching method for wide-area networking. Acting as a DTE, the router encapsulates data in a frame and transmits that data while serving as a source device. When it is a destination device, it receives frames and de-encapsulates them. The XSR's implementation of Frame Relay employs DTE support of the User Network Interface (UNI) for PVC (DLCI) connections with Committed Information Rate (CIR) traffic shaping, BECN/FECN congestion control, standard LMIs ILMI, ANSI Annex D, CCITT Annex A, FRF.12 fragmentation, periodic keep-alives, multi-protocol interconnect over Frame Relay, Frame Relay Inverse ARP, multiple logical interfaces over the same physical port, QoS including standard FIFO queuing or IP QoS on DLCIs, DCE support, and Frame Relay over ISDN.

- *Quality of Service* - The XSR provides traffic classification using IP Precedence and DSCP bits, bandwidth control via metered, policed and prioritized traffic queues, and queue management utilizing Tail Drop, Random and Weighted Early Detection (RED, WRED). Also, QoS on Input including *classification* based on class maps (similar to QoS on Output), *marking* per traffic flow (DSCP and IP precedence fields), and *policing* per traffic class, and QoS over VPN.
- *ADSL* - Three PDU encapsulation types are available for ADSL: PPP over ATM (PPPoA), PPP over Ethernet (PPPoE), and Routed IP over ATM (IPoA). Also supported: POTS and ISDN circuit support, ATM Frame UNI (FUNI) data framing format, OAM cells: AIS, RDI, CC, Loopback over F4 and F5 flows, up to 30 ATM Permanent Virtual Circuits (PVCs), ATM UBR traffic class, ATM Adaption Layers 0, 5, response to inverse ARP requests, and maintenance of SNMP Interface and Interface Stack tables.
- *Virtual Private Network* - The XSR supports VPN tunnels using L2TP, PPP or IPSec protected by DES, 3DES, RC4, MD5, AES or SHA-1 encryption. VPN tunnels are authenticated/ authorized for credentials using pre-shared keys or Public Key Infrastructure (PKI) certificates (Microsoft and Verisign). Also supported: DF Bit override, OSPF over VPN, GRE over IPSec, interaction between firewall/NAT/VPN, ToS bit preservation, IP helper on VPN interfaces, IETF/Microsoft-compatible NAT traversal for L2TP, and QoS over VPN.
- *Security* - In its firewall feature set, the XSR provides stateful firewall protection against a variety of Denial of Service attacks, FTP and H.323 ALG support, application command filtering for FTP, SMTP, NNTP, HTTP, onboard URL filtering, firewall logging and authentication, and supports standard and extended Access Control Lists to manage network access. Also supported: AAA for firewall, Console/Telnet and SSHv2 users, and dynamic reconfiguration of firewall policy without having to restart the code.
- *Dialer Interface* - Dial Services are a cost-saving alternative to the leased line connection between two peers and they can be implemented for different types of media for both inbound and outbound connections. The XSR supports incoming calls on analog modems.
- *Dial Backup* - The dialed backup feature provides a backup link over a dial line. The backup link is brought up when a failure occurs in a primary link, and it is brought down when the primary link is restored. This feature is supported for PPPoE to enable cable backup over FastEthernet/GigabitEthernet sub-interfaces. Also supported: Dialer Watch, ISDN callback, and dialer interface spoofing.
- *ISDN* - The XSR's BRI and PRI switched and leased lines set up and tear down calls, usually under the control of the Dialer. The XSR's ISDN services BRI and PRI lines with a 1, 2 or 4 port Channelized NIM card for PRI lines, 1 or 2 port BRI-S/T NIM card, or 1 or 2 port BRI U NIM card. Also supported: Circuit Mode Data (CMD) channel (DS0s) switching by the CO to the destination user for the duration of the call, outgoing calls supported for Backup, DoD/BoD, incoming calls routed to the correct protocol stack based on called number/sub-address and calling number/sub-address, permanent B-channel support, i.e. 64 or 128 kbps lease line (each BRI port can be set for CMD or Leased-Line mode of operation), BRI supported switches: ETSI, TEI auto-negotiated for BRI, automatic configuration of Q.921/Q.931 (Layer 2/Layer 3) by selection of switch type, PRI supported switches: ETSI, NI, DMS100, NTT, automatic configuration of PRI restart and maintenance modes, Fixed TEI of 0 for PRI, ISDN switched and leased line connections, bandwidth optimization through Dial on Demand (DoD), Bandwidth on Demand (BoD) and Bandwidth Allocation Protocol (BAP), security through caller ID, call monitoring, ISDN callback, Multilink PPP (MLPPP), per call activation for NTT switches, and Frame Relay over ISDN. The XSR also provides: asynchronous serial support through an external modem, synchronous serial, Unnumbered Interface Addressing, PPP encapsulation, authentication from XSR's database for PAP and CHAP, dialer profile support, configurable redialer, ISDN callback, dialer watch, and dialer interface spoofing.

2

Managing the XSR

The XSR can be managed via three interfaces with varying levels of control: the Command Line Interface (CLI) for full configuration, performance and fault management; the Simple Network Management Protocol (SNMP) for remote monitoring and firmware upgrades, and the Web for gathering version information.

Utilizing the Command Line Interface

The Command Line Interface (CLI) is a widely used tool to access and control configurable parameters of the XSR. You can access the CLI three ways:

- Directly connect to the Console port via an asynchronous terminal
- Over the network using Telnet or SSH via a LAN or WAN interface

Connecting via the Console Port on XSR Series

For ease of use when first setting up the XSR, you can directly connect the Console port to an asynchronous terminal (via Microsoft's HyperTerminal or other program) with the following values: 8 data bits, no parity, 9600 bps, 1 stop bit, flow control - none. Because the Console port is wired as a DCE with a DB-9 connector, a *DB-9 null modem* cable is needed to attach a standard PC COM port to the Console port.

Although a login (*admin*) is required to make this connection, for additional security you can later delete the *admin* user as well as disable Telnet sessions through the Console.

Using the Console Port for Dial Backup on the XSR 1800 Series

Optionally, you can set up the Console port as a dial-in *WAN* interface for dial backup purposes (refer to the following **Caution**). This option is avaialable only on the XSR 1800 series. For details, see Chapter 3 of the *XSR Getting Started Guide*.

Caution: When you enable the Console port as a WAN port, you can no longer directly connect to it because it is in data communication mode. Your only access to the CLI will be to Telnet/SSH to an IP address of a configured port. Also, if **startup-config** does not set up any of the ports properly and sets up the console port as a serial port, you will no longer be able to login and will have to press the Default button (1800 Series) to erase your configuration. If you opt to connect a modem to the Console port with the required *straight-through* cable, configure the sample settings described below.

Note: This feature is not supported on the XSR 3000 Series.

Using the Console Port to Remotely Control the XSR

The XSR's Console port can also be connected to a modem for the purpose of remote console control. Make the connection with a *straight-through* cable and enter the following XSR commands:

```
XSR(config)#interface serial 0
XSR(config-if<S0>)#physical-layer async
XSR(config-if<S0>)#clock rate 9600
XSR(config-if<S0>)#encapsulation ppp
XSR(config-if<S0>)#ip address 192.168.10.1 255.255.255.0
XSR(config-if<S0>)#ppp timeout retry 20
XSR(config-if<S0>)#no shutdown
```

Set the modem switches as follows:

- DTR override (DTR is ignored)
- No echo offline commands
- Auto answer on first ring
- Carrier Detect normal
- Load factory defaults
- Dumb mode (AT command mode disabled

Connecting a Serial Interface to a Modem

The XSR supports attaching a Serial (RS-232) NIM interface and modem to accept inbound and outbound data calls. Modem switches and the *receiving-side* XSR are configured exactly as described in "Using the Console Port to Remotely Control the XSR" except that the **`interface serial 0`** command must instead specify **`interface serial 1`** (or higher). S*traight-through* cabling is required again for the connection.

On the *calling-side* XSR, enter the following commands:

```
XSR(config)#interface serial 1/1
XSR(config-if<S1/1>)#physical-layer async
XSR(config-if<S1/1>)#clock rate 38400
XSR(config-if<S1/1>)#encapsulation ppp
XSR(config-if<S1/1>)#dialer pool-member 1
XSR(config-if<S1/1>)#no shutdown
XSR(config-if<S1/1>)#dialer interface 1
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer string <your phone number>
XSR(config-if<D1>)#address 192.100.10.2 255.255.255.0
XSR(config-if<D1>)#no shutdown
```

And enter the following calling-side modem switch settings:

- DTR normal (DTR disconnects)
- Echo offline commands
- Verbal result codes
- Display result codes
- Carrier Detect normal
- AT command mode enabled

Terminal Commands

If you want to display identification information about the current terminal connection, issue the **`show whoami`** command. Refer to the *XSR Getting Started Guide* and *XSR CLI Reference Guide* for more information on commands.

Connecting via Telnet

Once the XSR is properly configured with a valid IP address, you can remotely connect to the CLI via Telnet using the default user *admin* with no password. Later, you can create users with the **`username`** command.

Although up to five concurrent Telnet/SSH and one Console sessions are supported, if more than one session is running simultaneously (including the Console session), only one session permits configuration changes. Any other session could only view configuration settings. This prohibition applies to all commands that make changes to the configuration and is limited to Global mode. For example, if a user is in Global mode and another user tries to enter Global mode, the second user will get the following error message:

```
XSR#config

Configuration is currently locked by user admin. Please try later.
```

Also, in order to ensure that an administrator can always login to the router, one of the five permitted Telnet or SSH sessions is always reserved for the administrator.

That is, if the first four sessions are regular users, the fifth session will allow only the administrator to login. But if one of the first four is logged in as administrator, then the fifth session can be any user. You can also Telnet from the XSR to a server by using the **`telnet ip_address`** command. It is a useful utility for diagnostics. Be aware that the router will try to make a Telnet connection for 70 seconds.

Connecting via SSH

Secure Shell (SSH v2) encrypts the link to the XSR so it is a more secure alternative to Telnet for remote connections. To activate SSH, invoke the following commands:

- Create a host key pair with **`crypto key dsa generate`**
- Add an *AAA* user including a password and privilege level with **`aaa user`**, **`password`** and **`privilege 15.`** You can also create a user in the *CLI* database with the **`username`** command.
- Enable SSH access with **`policy ssh`**
- Enable local authentication with **`aaa client ssh`**
- Load an SSH client application on your PC to connect with the XSR
- *Optionally*, you can disable Telnet with **`ip telnet server disable`** for higher security
- *Optionally*, if you are enabling the firewall feature set you can configure an Access Control List (ACL) to allow a single host SSH access to the XSR by entering these commands:

```
XSR(config)#access-list 100 permit tcp host 192.168.1.10 eq 22
XSR(config)#access-list 100 deny tcp any host 192.168.1.10 eq 22
XSR(config)#access-list 100 permit ip any
XSR(config)#interface fastethernet 1
XSR(config-if<F1>)#ip access-group 100 in
```

PuTTY and other shareware programs are compatible with the XSR's SSH server.

Refer to the *XSR Getting Started* and *CLI Reference* guides for more details.

Accessing the Initial Prompt

The CLI is protected by security. Before you can access EXEC mode, you must enter a valid password. This mode lets you test basic connectivity of the XSR but does not permit you to change or monitor the router's configuration. Access to enhanced commands is permitted only if you enter Privileged EXEC mode by entering **`enable`**. You can logout at any time by entering **`exit`** while in EXEC mode. Refer to Table 2-1 for session limits.

Table 2-1 Session Limits

Parameter	Limit
Total number of CLI Telnet/SSH sessions permitted	5
SSH sessions permitted with 32 MBytes of memory	1
Console sessions permitted	1
Number of Telnet sessions reserved for administrators	1
Terminal auto-logout timeout value (configurable)	1800 seconds

The **`show resources`** command displays all resources created and the memory utilized. Refer to the *XSR CLI Reference Guide* for more details.

Synchronizing the Clock

XSR 1800 and 3000 Series routers have an on-board Real Time Clock (RTC) chip with which to keep accurate time across the network. As an alternative to accessing a public time server, you can utilize the RTC as a time reference for isolated networks employing the Simple Network Time Protocol (SNTP). XSR 1200 Series routers do not carry an RTC chip, however, and for these you ***must*** synchronize from an external source.

The XSR supports both SNTP v3 client and server (unicast mode) to synchronize logs on routers, switches and other network devices. Scenarios include isolated "flat" or hierarchical topologies as well as public time-server schemes. A *flat* scenario, for instance, might have Router A (XSR 3150) acting as a server to both Router B (XSR-1220) and Router C (XSR-1220) which makes a client request through Router B via an ISDN connection. A *hierarchical* scenario, on the other hand, might have Router B acting as both SNTP client and server, making a client request of Router A and taking a client request from Router C over ISDN.

Note: We recommend using an NTP time server over an SNTP server with an RTC as its primary source for greater accuracy. In this respect, the default stratum is set internally to 10.

SNTP client and server are configured with the **`sntp-client server [primary | A.B.C.D.][alternate | A.B.C.D.]`** and **`sntp-server enable`** commands, respectively. Also, you can also set the interval between client requests with the **`sntp-client poll-interval`** command.

Refer to the *XSR Getting Started Guide* for a configuration example and the *XSR CLI Reference Guide* for command details.

Managing the Session

A first-time CLI session is set up with default attributes; e.g., the session is set to time out after 1800 seconds of idle time. You can reconfigure session values such as create users, passwords, and login banners, and set Telnet and Web access. Refer to the *XSR CLI Reference Guide* for details about these commands.

Remote Auto Install

The Remote Auto Install (RAI) feature automatically retrieves a centrally managed configuration specifically created for the node's operation in your network. Basically, RAI sends a configuration file from a TFTP server for configuring the remote XSR. This file is then placed in the **`Flash:`** directory as the **`startup-config`** and run via the normal startup process. RAI can be performed by one of three methods: over a Frame Relay network using the lowest numbered serial port, a PPP connection using the lowest numbered serial port, a PPPoE connection using the ADSL network, or over an LAN connection using the lowest number Ethernet port.

RAI simplifies management and deployment of the XSR. Because device configurations are stored centrally on the TFTP server, re-configuring the XSR requires only a remote reboot. Installing the device at a new location involves deploying a new **`startup-config`** file with a corresponding name (based on the serial number or hostname) and rebooting the XSR.

Described in further detail, these choices are:

- *RAI over Frame Relay* is performed over a Frame Relay network. The RAI central site includes a Bootp server on a DLCI to deliver the local IP address for the branch (remote) site in order to communicate with the configuration management server.
- *RAI over PPP* can be performed over either leased or dial-up lines. *Leased line RAI* operates similar to Frame Relay RAI in that it is perfomed over a serial link via a leased Telco line. Dial-in RAI occurs where a designated port is configured and waiting for the central site to dial in. Dial in can utilize a modem attached to the XSR's serial or switched BRI/ PRI interfaces.
- *RAI over ADSL* can be performed over the ADSL network. XSR uses the auto discovery mechanism to identify an existing PVC on the ADSL line and tries to retrieve the startup configuration using PPPoE and TFTP over that PVC.
- *RAI over Ethernet* utilizes a DHCP client/server methodology to quickly retrieve a particular file from a TFTP server that will be used to configure the remote XSR.

Refer to the "Software Configuration" chapter of the *XSR Getting Started Guide* for a RAI configuration examples and *phased* output from the program.

RAI Features and Requirements

At the branch site, the XSR supports the following Frame Relay IETF features:

- Operates on Serial NIM interfaces only - lowest slot/card/port only.
- Standard physical Serial media-types.
- DTE LMI type ANSI, ILMI, Q933 supported.
- Up to 30 DLCIs supported on Frame Relay (FR) connection.
- Bootp client.
- Reverse DNS client.
- TFTP client.

- Backwardly compatible/transparent to those not requiring RAI.
- Console display of RAI progress.
- Console interrupt of RAI process at any time.
- CLI configurable RAI loading. Persistent, 5-minute try, and none (disable).
- No rebooting required to activate configuration.
- Hostname choices are flexible to include/exclude domain and canned names as well for the configuration file.
- The configuration file is examined for the proper target node identification to minimize the chance of being locked out of remote access.

At the central site, the XSR supports the following Frame Relay IETF serial interface features:

- Operational on all physical interfaces which support Frame Relay - T1, T3, and Serial.
- Bootp server configurable on a per DLCI basis.
- DLCI limit based on standard LMI limitation. (ILMI, AUTO - 190, ANSI, Q933A - 300)
- Bootp server.
- IP helper address for forwarding to DNS and TFTP servers.
- Configurable to Inverse ARP and No Inverse ARP on a DLCI basis.

At the branch site, the RAI ADSL has the following features:

- F5 OAM end-to-end or segment cells are used to discover the link VPI and VCI numbers.
- PVC connections should be set with the VPI ranging from 0 to 128 and VCI from 32 to 128.
- RAI requires the ADSL line to be connected to the first port of the ADSL card.
- ADSL RAI works with PPPoE SNAP or MUX. The PPPoE server must be reachable from the DSLAM either by ATM or by bridging. ADSL RAI does not work with IPoA or PPPoA.
- The local IP address is obtained using PPPoE IP address negotiation.
- The serial number of the XSR is the initial username and password for CHAP/PAP PPPoE.
- The file name of the **`startup-config`** sought from the TFTP server is the serial number of the branch XSR.

At the central site, the RAI ADSL requires the following features:

- The device terminating the ADLS connection (mostly likely DSLAM), has configured and enabled PVC with F5 OAM cells.
- The PPPoE server provides a pool of IP addresses for IP configuration of the remote XSR.
- The PPPoE server authenticates the remote XSR with CHAP or PAP using the XSR's serial number as the username (hostname) and password.
- On the interface where PPPoE is terminated, broadcasting should be allowed by helper address or some other method in order for TFTP discovery packetsto find the TFTP server.
- The name of the **`startup-config`** files stored on the TFTP server should match the serial number of the branch XSR.

DHCP client over the LAN:

- Operational over an Ethernet interface *only* on the lowest slot/card/port *only*.
- Uses the options field for TFTP server, IP address, host name and config file.
- Optionally uses Reverse DNS if options are not populated.

At a branch site, the XSR supports the following features over a PPP IETF serial interface:

- Operational on Serial NIM interfaces only - Lowest slot/card/port only.
- Supports standard physical Serial media-types.
- Supports Sync/Async interface type.
- Supports the following clock rates (in bps) for the Async interface:

– 9600, 14400, 33300, 28800, 57600, and 115200 baud.

- Supports PPP and MLPPP negotiation via LCP.
- Supports IP address negotiation via IPCP.

RAI Requirements on the XSR

The branch XSR retrieves the configuration file by means of a TFTP client. The TFTP transfer requires a specific *file name* and unique local *IP address* to communicate with a remote server.

The branch XSR must get the local IP address from the central site. How it is done differs between RAI methods. FR RAI uses the Bootp server residing on the central site node, RAI DHCP gets the local IP through DHCP negotiation, while PPP-based RAIs facilitate PPP IP address negotiation. At the end of the process, the interface on the branch XSR is configured with an IP address and can communicate with the TFTP server.

The file name is the name of the startup file that is transferred from the TFTP server to the branch XSR. It derives from the XSR hostname. As in the case of the local IP address, the branch XSR must get the hostname from the central site. RAI uses the rDNS for this purpose. DNS servers map nodenames/domains and IP addresses - typically, you provide a hostname and the DNS server returns the IP address. But rDNS lookup used by RAI offers an IP address and DNS returns the *hostname.domain*. RAI ADSL is an exception to this process since is not required to perform rDNS during the RAI process because it uses the serial number of the XSR as the name of the **`startup-config`** file. In the case of RAI over Ethernet, where DHCP is configured to provide the configuration file, no rDNS is required because **`config-file`** is the file name.

In general, accessing the DNS or TFTP server requires the client (in this case, the branch XSR) to know the IP address of the server. Since the branch router has no configuration and no knowledge of the server address, it must broadcast a request for DNS or TFTP access. For RAI to work correctly, the terminator of the connection (other end of the FR DLCI, PPP or PPPoE point-to-point connection) is required to channel the broadcast to a specific address. This is done by entering the **`ip helper-address`** command at the central site.

How RAI Components Work

Frame Relay (Remote Router)

The FR interface keeps the FR link alive via proper protocol handling of LMI. If the connection fails, or new DLCIs are added to the list, the FR interface will notify RAI of the changes.

RAI checks each DLCI, up to 30, on a given interface for a *Bootp response*, an *rDNS server* and a *TFTP server* with a configuration file. The first DLCI that accomplishes this will be chosen. If the connection fails, RAI will reset itself and restart at Phase 1, next media-type.

If the DLCI does not have all of the correct servers and responses, the next DLCI on that interface is queried. The last DLCI in the list will loop around to the first DLCI to be continued indefinitely in *persistent* mode and for five minutes in *non-persistent* mode as set by the **`netload`** command.

A node with no **`startup-config`** will default to persistent (forever) mode. A node with no Serial NIM card installed will abort RAI processing immediately and proceed to the login prompt after executing a local startup-config file if it exists.

While in RAI mode, inverse ARP, pings, and other packets entering the port may be optionally responded to depending on the phase of the process. It is not recommended that you rely on the proper response to these packets.

Bootp Client

The Bootp client sends up to five broadcast bootp requests with the MAC address of the first Ethernet port in the node as the client's unique hardware address. The MAC address is chosen this way for compatibility with bootp servers to be associated based on the hardware address. In newer FR/routers which provide Bootp server functionality inside the FR configuration, this hardware address field is ignored and responded to locally with static mapping.

In the Bootp response, the boot file provided is ignored by the client. The IP address assigned by the Bootp server in the bootp reply is used as the client's IP address.

Reverse DNS Client

The rDNS client sends a broadcast request with the discovered IP address from bootp as the source. This rDNS request occurs five times before quitting. The broadcast relies on the central site router to have a helper IP address configured to forward to the correct server. Use the **`ip helper-address`** command to set the DNS server IP address.

TFTP Client

The TFTP client broadcasts a request for the **`hostname-config`** file first. The TFTP server responds with a unicast reply, from then on unicast is used for both the client and server. The TFTP broadcast relies on the central site router to have a helper IP address configured on the corresponding interface to forward to the correct server.

If the file is not found or is read-protected, the TFTP client will try the additional file types shown below. Once all the names have been exhausted, the next DLCI from FR will be tried.

- *Hostname-confg*
- *Hostname.domain-confg*
- *Hostname.cfg*
- *Hostname.domain.cfg*
- *enterasys-confg*
- *enterasys.cfg*

If the server does not respond, RAI tries the next DLCI, renegotiating bootp and rDNS as before.

Frame Relay (Central Site)

At the central site, the node is a fully configured router to accept broadcast bootp requests from a remote router. If bootp service is to be provided by an external server then omit this parameter.

With bootp enabled, DHCP relay and server functionality is disabled on this DLCI for broadcast packets entering from this DLCI. Unicast bootp requests are still forwarded to the server.

Configuration on a DLCI by DLCI basis is supported for a bootp response, requiring that a statically-mapped DLCI number be configured with a corresponding IP address. This mapping is valid for both point-to-point and multi-point sub-interfaces.

Since the XSR does not support an internal rDNS or a TFTP server, you must map the helper address to the appropriate server in sub-interface mode with **`ip helper-address A.B.C.D`**.

DHCP over LAN (RAI over Ethernet)

The DHCP over LAN client/server RAI employs a very fast installation for providing a running configuration to an XSR. RAI over Ethernet retrieves a particular file from a TFTP server that will be used to configure the remote router. This file will then be copied to Flash as the **`startup-config`** and executed via normal startup procedures.

DHCP Client *must* be set on the XSR's first Ethernet port. It sends a DHCP request several times up to 18 seconds and if no response is received, RAI will proceed to the next RAI connection type.

The DHCP Client seeks the following information:

- *IP Address* - This *mandatory* data is required because the DHCP Server *must* assign a *static MAC address* to the IP address
- *Config file name* - This *optional* data is needed otherwise a *reverse DNS server* is required.
- *TFTP server address* - This *optional* data is needed otherwise TFTP will send its initial message.
- *Hostname* - This *optional* data is not needed if the *config file* or an *rDNS server* are available

In practice, one of the following scenarios is played out:

- If the client receives an IP address *only*, it will request the *hostname.domain* via reverse DNS and then a TFTP broadcast will be sent to find the file.
- If the client receives the config file name as well as the TFTP server address, then the TFTP request will be initiated as a unicast message containing the DHCP config file name.
- If the client receives the hostname, reverse DNS will not be tried. The hostname will be used only if the client config file name is not provided.

The DHCP application usually performs dynamic address assignment on a first-come, first-serve basis from an address pool. For RAI to work properly, the DHCP server must statically map the XSR's MAC address to the IP address that will be used by reverse DNS. Failing to do so will cause the XSR to try retrieving the wrong file from the TFTP server.

The DHCP Server seeks the following information:

- *IP Address* - This *mandatory* data is required because the DHCP Server *must* assign a *static MAC address* to the IP address
- *Config file name* - This optional data is supplied by DHCP Option 67.
- *TFTP server address* - This optional data is supplied by DHCP Option 150.
- *Hostname* - This optional data is supplied by DHCP Option 12.

The XSR's DHCP server feature is used by RAI over Ethernet but if a PC/Unix/Linux-based application is available and meets the criteria for static assignment of IP addresses based on MAC addresses, it may be used.

PPP RAI over a Leased Line

PPP over a leased line performs similarly to Frame Relay RAI over a serial link via a leased Telco line. When PPP negotiation is successful, a point-to-point connection is established from the remote XSR to the central router. Then the remote XSR can obtain its IP address. But, you must assign a default peer IP address in the central router to give the remote XSR a valid IP address.

After the remote XSR acquires the address, RAI proceeds by sending DNS and TFTP requests.

At the central site, the node will be fully configured with PPP encapsulation. In case multilink is required, the PPP multilink option is enabled and a multilink interface created. The central router is also configured with a default IP address over the serial interface for non-multilink PPP circumstances and over a multilink interface for a multilink PPP scenario.

PPP RAI over a Dial-in Line

Dial-in PPP RAI is performed as a background task in that the designated port is configured and waiting for the central site to dial in while the other RAI type (Ethernet/Frame Relay/PPP Leased line) is still operating on the other ports. As soon as the dial-in port reaches a PPP up state, the rest of the RAI process is terminated.

Dial-in line RAI requires either a modem attached to the serial interface or the switched BRI/PRI interface. Similar to leased line PPP RAI, successful PPP negotiation provides the point-to-point link from the remote XSR to the central router. Authentication may then be required by the central site. After successful authentication, the remote XSR can obtain the IP address through negotiation but a default peer IP address must be assigned in the central router to provide the remote XSR with a valid IP address.

Dial-in PPP RAI is directed to a port by the following priority with only one port type defined:

- The first *BRI* port found in the XSR or,
- The first *PRI* port found in the XSR or,
- The *second serial port* found on the XSR (since the first serial is defaulted to be used for Frame-Relay/PPP Leased line RAI).

The XSR's Dialer interface (D*x*) is configured to handle a dial-in call and set for PPP encapsulation to accept either CHAP or PAP authentication. While being authenticated by the central site, the serial number of the remote XSR will be used as the user name and the password. The central site must decide which PPP authentication type to use or none at all.

The Dialer interface's IP address is negotiated and is assigned via PPP negotiation similar to PPP leased line RAI.

Refer to the *XSR Getting Started Guide* for configuration examples.

PPP RAI over ADSL

RAI ADSL is performed over the ADSL line using PPPoE. Similar to other RAI methods, RAI tries to configure a point-to-point connection in order to download the startup file from the TFTP server. To reach the TFTP server, RAI ADSL must connect to the DSLAM with a proper PVC and establish the PPPoE session with the PPPoE server. The PPPoE server that terminates the PPPoE connection for the XSR handles the TFTP request and directs it to a proper TFTP server (that may or may not be on the same device as the PPPoE server).

When the XSR boots without the **`startup-config`** and the ADSL card is installed, the first RAI method tried is RAI over ADSL. If that fails, RAI moves on to other available RAI methods. RAI ADSL passes through four phases to configure the XSR during which it displays console messages about the state of the process.

The *first* phase establishes a physical connection (training) on the ADLS line. RAI ADSL attempts a physical connection on the first port of the ADSL card, waiting one minute for training to succeed. If it fails, RAI abandons ADSL RAI and moves to the next available RAI method.

After training with the DSLAM, RAI must configure a proper PVC channel on the ADSL line. In this *discovery* hase, PVCs on a particular ADSL line are preconfigured on the DSLAM that terminates the ADSL physical line. In order to discover VPI and VCI numbers for the PVC, RAI ADSL sends F5 OAM cells on the line and collects responses (if any) from the the DSLAM. RAI searches PVCs starting from VPI = 0/VCI = 30 and stops on VPI=128/VCI=128. Because ADSL RAI conducts a linear search of the VPI/VCI space, searching for a PVC with high VPI/VCI values can be lengthy. Currently, RAI does not support preconfigured VPI/VCI numbers.

RAI stays in discovery phase until it finds the first PVC that responds on OAM cells or until it exhausts the PVC space in which case it abandons ADSL RAI and moves to the next available RAI method.

In the *port setting* phase, RAI configures sub-interface 1 on the first port of the ADSL card (**`atm 0.1`**) with the discovered PVC. If there is more than one discovered PVC, RAI begins with the first one. ADSL RAI tries two PPPoE encapsulations - SNAP and MUX. If authentication is required, RAI ADSL uses CHAP or PAP and takes the serial number of the XSR as its username and password - the PPPoE server must be configured with the XSR serial number to authenticate successfully. If authentication succeeds, the IP address is retrieved from the PPPoE server and the IP layer comes up. RAI ADSL waits one minute for authentication and the IP connection to come up. If it times out, it proceeds to the next encapsulation, or if both encapsulation types fail, for that PVC to try the next discovered PVC. In a case where there are no other PVCs to try, RAI abandons ADSL RAI and moves on to the next RAI method.

The *final* phase involves TFTP, where RAI downloads the startup file. This phase is common to other RAI methods. Because TFTP broadcasts the request for the TFTP server, it is important that the server terminating the PPPoE session direct this request to the TFTP server (using the IP helper address). The startup file name is the serial number of the device.

If TFTP fails and PVCs exist that were not previously tried for configuration, RAI returns to PPPoE negotiation and reconfigures the ATM 0.1 interface with a new PVC. Otherwise, it abandons ADSL RAI and moves on to the next RAI method.

CLI Editing Rules

To use the CLI efficiently, be aware of the following rules:

- *Case-sensitivity*: CLI commands are *not* case-sensitive. For example, you can enter either **`SHOW VERSION`** or **`show version`** to display the XSR's software revision. But, some *parameters* may be case sensitive. For example, entering **`snmp-server community public`** is different from **`snmp-server community PUblic`**
- *Command Abbreviation*: You can abbreviate commands and keywords to the minimum number of characters that define a unique abbreviation. For example, you can abbreviate the **`hostname`** command to **`hostn`** (but you cannot abbreviate to **`hos`** because other commands also start with the letters **`hos`**).
- *Output Display*: By default, output data are displayed one page at a time if the data occupies more than one page. In this case, you can use the spacebar to scroll down to the next page or press ENTER to scroll down one line at a time. The default page size is 132 characters wide, 23 rows high and they are configurable in a range from 0 to 512 characters using the **`terminal`** command. Refer to the *XSR CLI Reference Guide* for more information about the command.

- *Command Recall*: Non-help commands are stored in the command history list buffer up to the last 32 commands. You can recall and edit previous commands using shortcut keys. For example: **Ctrl+p/Ctrl+n** will list the previous/next command respectively and can be applied repeatedly. The up-arrow or down-arrow keys provide the same feature if your terminal supports these keys.
- *Tab Completion*: Pressing the **TAB** key or **CTRL+I** completes a command. In case of an ambiguous match, the word is completed up to the character which leads to ambiguity. For example, **hostname** and **hostDos** share the letters **host**, so tab completion completes the "command" **ho** to **host**.
- *Carriage Return/Enter*: Pressing the carriage return/ENTER key signals the end of a CLI command.
- *Help Symbol*: At any point you can enter the**?** character to prompt for a list of possible commands/parameters at a particular mode.
- *Error*: Proper error messages are displayed if the command could not be issued due to syntax errors or invalid values made by the user.

Typing these characters will produce output as follows:

```
XSR#showFIioLLJl
XSR#showFIioLLJl
                ^
% invalid input detected at '^' marker
XSR#
```

- *CLI Terminal Editing Command Keys*: Refer to the following table for these useful shortcuts.

Table 2-2 CLI Shortcuts

Command	Description	Command	Description
Ctrl + a	Move cursor to beginning of line	Ctrl + p	Previous CLI command in history
Ctrl + b	Move cursor back 1 character	Ctrl + r	Echo current line
Ctrl + c	Same as the CLI **end** command	Ctrl + u	Delete all characters before cursor
Ctrl + d	Delete 1 character after cursor	Ctrl + w	Delete 1 word before cursor
Ctrl + e	Move cursor to end of line	Ctrl + x	Delete all characters before cursor
Ctrl + f	Move cursor forward 1 character	Ctrl + y	Restores the most recently deleted item
Ctrl + h	Delete 1 character before cursor	Ctrl + z	Same as the CLI **end** command
Ctrl + I	Tab completion	Del	Delete a character
Ctrl + k	Delete all characters after cursor	Esc + b	Move cursor back 1 word
Ctrl + l	Echo current line	Esc + d	Delete to end of word at cursor
Ctrl + n	Next CLI command in history	Esc + f	Move cursor forward 1 word

Setting CLI Configuration Modes

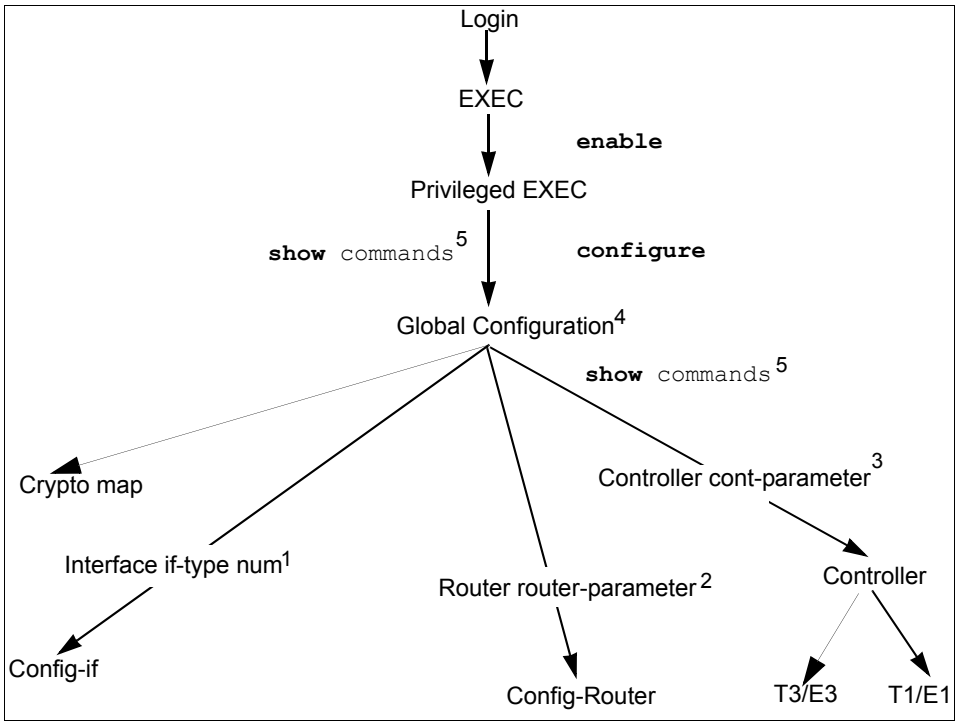
The CLI provides modes of operation permitting a subset of commands to be issued from each mode. Also, you can issue *any command* and acquire *any mode* if the command entered or mode acquired subscribes to the same parent. For example, you can issue the **interface serial** command at Crypto Map mode because both Serial Interface and Crypto Map modes subscribe to Global (config) mode. Table 2-3 describes a few primary modes of operation.

Table 2-3 CLI Configuration Modes

Mode	Function	Access Method	Prompt
User EXEC	Password-protected mode: •Changes terminal settings •Performs basic tests •Displays system information	Login process	**XSR>**
Privileged EXEC	This mode: •Sets system operating values •Shows configuration parameters •Saves/copies configurations	Enter **enable** in User EXEC	**XSR#**
Global	Sets system-wide values. Save changes after a reboot by copying the running-configuration to the startup-configuration	Enter **configure terminal** in Privileged EXEC	**XSR(config)#**
Interface	Modifies/assigns port parameters on a port-by-port basis	Enter **interface interface-type <port#>** in Global mode	**XSR(config-if<xx>)#**
Router	Sets RIP, OSPF or BGP parameters	Enter **router rip/ospf** in Global mode	**XSR(config-router)#**

Refer to Figure 2-1 for a graphic example of configuration modes.

Figure 2-1 Partial Configuration Mode Tree



The footnotes below refer to command options cited in the illustration.

1. The interface type can be one of the following: Serial, FastEthernet, GigabitEthernet, BRI, loopback, Multilink, VPN, Dialer, or ATM
2. Router parameters can be: RIP, OSPF or BGP
3. Controller can be one of the following: T1, E1, T3 or E3

4. Some attributes can be set at this level without acquiring other modes. For example: **access-list access-list-num [deny | permit] [parameter [parameter…]]**
5. **Show** commands can all be entered at EXEC, Privileged EXEC or higher modes.

User EXEC Mode

You enter User EXEC (or simply EXEC) mode after logging in. The following commands can be entered in EXEC mode: **disable, enable, exit, help, isdn, ping, show, telnet, terminal** and **traceroute**.

Privileged EXEC Mode

In order to make configuration changes, you must enter PRIV EXEC mode. Some configuration parameters specified in this mode apply to XSR global settings such as the system clock. Supported privileged EXEC mode commands are: **cd, clear, clock, configure, copy, debug, delete, dir, disable, enable, exit, help, isdn, more, no, ping, pwd, reload, rename, show, telnet, terminal, traceroute, verify**, and **write**.

Global Configuration Mode

In Global configuration mode you can configure many different resources such as ports, interfaces, and routing tables. The following levels are provided at the Global configuration level:

- *Interface Level*: At this level you can modify/assign specific port parameters on a port-by-port basis. You can enter this level by typing **interface interface-type <interface #>** at the Global configuration command prompt. For example, you can enter:

  ```
  XSR(config)#interface gigabitethernet 3
  ```

  The XSR will return the following prompt:

  ```
  XSR(config-if<G3>)#
  ```

- *Router level*: At this level you can configure parameters associated with the RIP or OSPF protocols. You reach this level by typing router [RIP, OSPF] in Global mode. For example:

  ```
  XSR(config)#router rip
  ```

  The XSR will return the following prompt:

  ```
  XSR(config-router)#
  ```

- Several other levels are available in Global mode including *AAA, Class-Map, Crypto, Dialer, IP,* and *Map-Class*. Many of these modes have additional levels nested within them.

Exiting From the Current Mode

Each of these commands exits from your mode but with different results:

- *Exit*: In each mode **exit** quits from the current to previous mode
- *End*: **end** always returns to Privileged EXEC from either Global or sub-configuration mode
- *Ctrl-Z*: Same as the **end** command
- Be aware that you need not always exit from a mode if your current and destination modes subscribe to the same parent in the mode tree.

Mode Examples

Consider the following examples to change configuration mode:

XSR>enable + *Acquires Privileged EXEC mode*

XSR#config terminal + *Acquires Global configuration mode*

XSR(config)#interface fastethernet 1 + *Acquires Interface mode*

XSR(config-if<F1>)#ip address 192.168.2.2.255.255.255.0
+ *Sets up the IP address and subnet mask for this FastEthernet port*

XSR(config-if<F1>)#exit + *Quits Interface mode*

XSR(config)#exit + *Quits Global mode*

XSR#disable + *Quits Privileged EXEC mode*

XSR> + *Returned to EXEC mode by previous command*

Note: In many cases, you are not required to exit from a mode to configure a command in another mode.

Observing Command Syntax and Conventions

The CLI command syntax and conventions on the XSR use the notation described below.

Table 2-4 Command Syntax and Conventions

Convention	Description
xyz	Key word or mandatory parameters (**bold**)
[*x*]	[ ] Square brackets indicate an optional parameter (*italic*)
[x | y | z]	[|] Square brackets with vertical bar indicate a choice of values
{x | y | z}	{ | } Braces with vertical bar indicate a choice of a required value
[x {y | z}]	[{ | }] Combination of square brackets with braces and vertical bars indicates a required choice of an optional parameter
(config-if<xx>)	*xx* signifies the interface type; e.g., **F1**, **G3**, **S2/1.0**, **D1**, **L0**, **BRI**, **PRI (T1/E1, T3/E3, ATM)**, **VPN**, etc.

In the following example:

show interface [dialer | fastEthernet/gigabitethernet | loopback | serial | bri | multilink | vpn {*interface-number*}]

- **show** and **interface** are keywords
- [**dialer**, **fastEthernet**, **gigabitethernet**, **loopback**, **serial**, **bri**, **multilink**, **vpn** and {*interface-number*}] are optional parameters

Syntactically, each line begins with one or more command keywords followed by a list of mandatory values (if any) and, lastly, a list or optional values. For example, the command below:

channel-group *number* **timeslots** *range* [**speed** {**56** | **64**}]

has a mandatory parameter value **number**, a mandatory parameter keyword and value pair **timeslots** *range*, an optional value offered as a keyword **speed** and value options of **56** or **64**.

CLI Command Limits

CLI commands on the XSR are bounded by the following:

- Total number of characters in a command line/help message: 299
- Total number of words in a command line: 127
- Number of command history entries recalled: 31
- Total number of characters in a prompt: 1023
- Total number of characters in system name: 31

Describing Ports and Interfaces

Technically, a *port* is a physical connector with some physical layer values. XSR ports are: FastEthernet (XSR 1800 Series) or GigabitEthernet (XSR 3000 Series), Async/Sync Serial, ATM, BRI, Loopback, T1/E1T3/E3, Console, and Null. An *interface* is a data and management plane comprising the physical, link and a part of the network layer. The terms are used interchangeably in this manual. The XSR supports multiple access types, including Fast/GigabitEthernet LAN, Frame Relay and Serial WAN access over Asynchronous, Synchronous, T1/E1, and Serial lines with async and sync access over permanent or dial lines. Generally, Frame Relay, PPP and Multilink PPP (Console optional) are for WAN access and PPPoE for WAN access over a LAN. Dial access is provided by ISDN BRI and PRI.

Supported Physical Interfaces

The XSR supports the following physical interfaces:

- *FastEthernet/GigabitEthernet* for LAN port consisting of Ethernet's physical, Mac (Layer-2), and IP layer functionality.
- *Serial for Sync or Async port*/line consisting of a Sync port/line's physical, Layer-2 (PPP) and IP layer functionality.
- *Serial for T1/E1 (PRI)* channel group consisting of its physical, Layer-2 (PPP or Frame Relay), and IP layer functionality.

Supported Virtual Interfaces

The XSR supports the following virtual interfaces:

- *Interface* dialer includes physical interfaces supporting dial connectivity from the dial port/line's physical layer functionality including dialing, Layer-2 (PPP), and IP layer functionality.
- *Sub-Interface* for an NBMA network. An NBMA network has multiple access over the same line but no broadcast capability. Examples of such networks are Frame Relay, X.25, and ATM. One physical interface comprises one or more sub-interfaces which in turn consist of one or more circuits on the physical interface. Sub-interface examples and its circuits are: one or more DLCIs forming a sub-interface, one or more X.25 PVC/SVCs forming a sub-interface and one or more VCs of ATM forming a sub-interface. This interface shares its physical layer functionality with other sub-interfaces, but each sub-interface has its own layer-2 (PPP or Frame Relay) and IP layer functionality.

Supported Ports

The XSR supports the following port types:

- Single-channel ports: Fast- and GigabitEthernet, Sync/Async serial, ATM
- Multiple-channel type ports: BRI, T1/E1

Numbering XSR Slots, Cards, and Ports

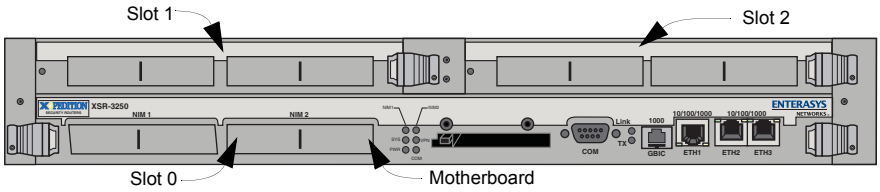
The syntax for XSR slot, card, and port numbering on the CLI, illustrated in Figure 2-2, is:

`slot#/card#/port#`

These parameters indicate:

- *slot #:* (motherboard is zero), (XSR 1800: 1/2, 3020/3150: 1/2, 3250: 0-2)
- *card #:* NIM card number (FastEth: 1/2, GigaEth: 1-6 from left to right)
- *port #*: NIM port numbers begin with zero

Figure 2-2 Slots on the XSR-3250



Slot, cards, and ports on the motherboard (Slot 0) are expressed as:

- Slot 0, Card 1 or 2, Port 1 or 2: **`0/1/1-4`** or **`1/1-4`** and **`0/2/1-4`** or **`2/1-4`**. The first 0 can be ignored

Slot, cards, and ports on the first XSR-3250 upper tray slot are expressed as:

- Slot 1, Card 1 or 2, Port 1-4: **`1/1/1-4`** and **`1/2/1-4`**

Slot, cards, and ports on the second XSR-3250 upper slot are expressed as:

- Slot 2, Card 1 or 2, Port 1-4: **`2/1/1-4`** and **`2/2/1-4`**

Setting Port Configuration Mode

The configuration mode setting for ports on the XSR is as follows:

- Single-channel ports are configured in Interface configuration mode.
- Multi-channel ports are configured in Controller configuration mode. A physical layer data stream is identified by channel using the **`controller`** command, and this channel group is then configured using the **`interface`** command.

Setting Interface Type and Numbering

XSR interface types and numbers are set as follows:

- Physical-type interface and port numbers are similar. Interface types are Serial BRI, ATM, PRI (T1/E1), or Fast/GigabitEthernet.

- Virtual Interfaces:
  - Loopback - Range 0 to 15. Interface type: Internal Loopback.
  - *Dialer* - Range: 0 to 255, Interface type: Dialer.
  - *VPN* - Range: 0 to 255, Interface type: VPN tunnel/Dialer.
  - *Multilink* - Range: 1 to 32767, Interface type: VPN tunnel.
  - *Frame Relay DLCI* - Range: 16 to 1007, Interface type: Serial/FR.
  - *Sub-interface*: Each sub-interface correlates with a physical interface, ranging as follows: ATM, BRI, and Serial - 1 to 30, Fast/GigabitEthernet - 1 to 64. The sub-interface number is *Port number.sub-interface number* for single channel serial, p*ort number.channelgroupnumber.subinterface number* for multi-channel.

Configuration Examples

The following examples display *minimal* interface configuration:

- FastEthernet Example

```
interface fastethernet 1 + Begins configuring interface/port 1
no shutdown + Enables the interface
```

- T1 Example

```
controller t1 1/0 + Begins configuring controller on NIM card 1, port 0
channel-group 3 timeslots 1, 3-6, 12 + Maps timeslots 1, 3, 4, 5, 6, and 12 to channel group 3
no shutdown + Enables the interface
!
interface serial 1/0:3 + Configures channel group 3 defined above
encapsulation ppp + Sets interface encapsulation type to PPP
no shutdown + Enables the interface
```

- T1-PRI (ISDN) Example

```
controller t1 1/0/0 + Begins configuring PRI NIM card 1, port 0
pri-group + Enables ISDN, sets all timeslots to map to channel groups on NIM
controller t1 1/0/0:23 + Maps T1 NIM to D-channel sub-interface
isdn switch-type primary-ni + Selects switch type
isdn pool-member 1 priority 100 + Adds a prioritized pool member to sub-interface
```

- Dialer Example

```
interface dialer 4 + Begins configuring dialer interface 4
ip address 11.1.2.2 255.0.0.0 + Sets IP address/subnet on dialer port
dialer pool 5 + Sets dialer 4 to use pool 5. Its members are physical ports
interface serial 2/0 + Configures serial interface on NIM card 2, port 0
encapsulation ppp + Sets interface encapsulation type to PPP
dialer pool member 5 + Serial 2/0 is now a member of dialer pool 5 and will eventually be used by dialer 4
no shutdown + Enables the interface
!
interface serial 2/1 + Configures serial interface on NIM card 2, port 1
encapsulation ppp + Sets interface encapsulation type to PPP
dialer pool member 5 + Serial 2/1 is now a member of dialer pool 5 and will eventually be used by dialer 4
no shutdown + Enables the interface
```

- BRI-Dialer (IDSN) Example

```
interface dialer 0 + Configures dialer interface 0
ip address 2.2.2.2 255.255.255.0 + Sets IP address/subnet on port
encapsulation + Interface/Sub-interface Behavior
```

XSR interfaces and sub-interfaces, channels and channel-groups are added and deleted differently depending on the particular interface. Interface characteristics are as follows:

- *T1/E1 Controller* - Creating a channel group adds a serial interface. For example, when you issue the command **`controller t1 1/0`**, the XSR automatically creates *channel group 0* with all available timeslots assigned to it. You can verify this by checking the running configuration where the following entry is displayed:

```
interface serial 1/0:0
```

  – You can create other serial objects by creating more channel groups. For example, by entering the following commands:

```
channel-group 0 timeslots 1-10 speed 64
channel-group 1 timeslots 11-20 speed 64
```

  – the following interfaces are added:

```
interface serial 1/0:0
interface serial 1/0:1
```

  – You can delete those controller interfaces *only* by removing the channel groups which automatically created them by entering:

```
no channel-group 0 + This automatically deletes Serial port 1/0:0
no channel-group 1 + This automatically deletes Serial port 1/0:1
```

  – To delete controller ports and all associated interfaces, you must remove the entire controller:

```
no controller t1 1/0
```

- *PRI NIM* - When configuring a PRI interface, a *pri group* is created as follows:

```
controller t1 1/0
pri-group
```

  – Creating a PRI group adds a serial interface internally, but it is not visible nor accessible to the user: **`interface serial 1/0:0`** is not displayed anywhere. But, the system resources associated with it remain in use until the *pri group* is deleted as follows:

```
no pri-group
```

- *BRI NIM* - When configuring a BRI interface, sub-interface addition/removal differs if you are configuring a leased line or switched connection.

  – *Leased line:* When configuring a leased line connection, serial sub-interfaces are created and are visible to the user:

```
interface bri 2/1
leased-line 64 + This adds serial port 2/1:1
leased-line 64 + This adds serial port 2/1:2
```

  – These serial interfaces are removed by deleting the entire controller. For example:

```
interface bri 2/2
no controller t1 2
```

– *Switched*: When configuring a switched BRI connection, three serial sub-interfaces are automatically created when you enter:

```
interface bri 2/1
isdn switch-type basic-ni1
```

– The following sub-interfaces are added:

```
interface serial 2/1:0
interface serial 2/1:1
interface serial 2/1:2
```

– These serial sub-interfaces are removed with the **`no isdn switch-type`** command:

```
interface bri 2/1
no isdn switch-type + This deletes serial ports 2/1:0, 2/1:1 and 2/1:2
```

Entering Commands that Control Tables

A number of CLI commands configure entries in tables such as **`arp`** and **`access-list`** in the XSR. Two types of tables are configurable:

- Single-instance table: The *ARP* table, for example, in which one table holds many rows and each row is a complete entry. Entries are not displayed in the same order they are entered.
- Multiple-instance table: The *Access-List* table, for example, in which there are multiple tables identified by number with each table containing many rows and each row is a complete entry. Entries are not displayed in the same order they are entered.

With few exceptions, you must be in Global mode before issuing table commands.

Adding Table Entries

Depending on the type of table configured, the parameter list can be optional or required. For example the ARP table has three required parameters and some optional values depending on the context. For example, using the following command:

```
arp ip-address mac-address
```

you may type:

```
XSR(config)#arp 1.1.1.1 e45e.ffe5.ffee
```

+ *where **arp** is the command and type of table to be filled or modified, **1.1.1.1** is the IP address corresponding to the MAC address e45e.ffe5.ffee.*

Note: ARP is a table type, as well as a command, that fills or modifies entries in the ARP table.

A second example is entered as follows:

```
XSR(config)#access-list 1 deny any
```

+ *where **access-list** is the command and the type of table to be filled or modified, **1** is the ID of the table to be modified, **deny** is the type of operation authorized and **any** is the host that should be denied.*

Deleting Table Entries

There are two ways to delete an entry from a table depending on the table type. Type (e.g.):

```
XSR(config)#no arp 1.1.1.1 e45e.ffe5.ffee
```

+ *removes the **arp** entry related to row **1.1.1.1.** where **no** is the command that negates the previous operation and **arp** is the associated table type. A second example is entered as follows:*

```
XSR(config)#no access-list 1
```

+ *removes access-list 1 where **no** is the command that clears the **access-list**.*

Modifying Table Entries

For some tables, you must first remove the entry then add the same entry with new values. For the ARP table the syntax is similar to the **add** command where you enter the command and entry ID with a new value which replaces the old value in the ARP table.

For example, typing the following:

```
XSR(config)#arp 1.1.1.1 e45e.ffe5.efef
XSR(config)#arp 1.1.1.1 e45e.ffe5.3434
```

+ *first creates an arp entry of **1.1.1.1** associated with MAC address **e45e.ffe5.efef**. Then, this entry is modified to be associated with the new MAC address e**45e.ffe5.3434.***

Displaying Table Entries

You can display ARP table, access-list table, gateway-type prefix table, IP routing table, and other entries at privileged EXEC mode.

For example, enter **show ip arp** displays the following output:

```
XSR#show ip arp
Protocol  Address          Age(min)  Hardware Address    Type   Interface
Internet  192.168.12.16    0         0001.f4fe.2716      ARPA   FastEthernet2
Internet  192.168.14.64    12        0001.f4ee.2764      ARPA   FastEthernet2
Internet  192.168.12.40    18        00b0.d0fe.e292      ARPA   FastEthernet2
Internet  180.180.180.1    59        0030.ee1f.ef61      ARPA   FastEthernet2
Internet  192.168.12.1     8         00e0.631f.a45a      ARPA   FastEthernet2
Internet  192.168.12.81    60        0030.85ff.ef61      ARPA   FastEthernet2
Internet  192.168.12.17    44        0001.f4ef.2717      ARPA   FastEthernet2
```

Managing XSR Interfaces

You must be in Interface mode before configuring XSR ports. To enter Interface mode, type the following, for example:

```
XSR#configure terminal
XSR(config)#interface FastEthernet 1
XSR(config-if<F1>)#
```

Ports can be enabled or disabled, configured for default settings, associated tables, clock rate, priority group, and encapsulation, for example. Refer to the *XSR CLI Reference Guide* for more details on Interface mode commands.

Note: All interfaces are disabled by default.

Enabling an Interface

The following command enables an interface.

```
XSR(config-if<S2/0>)#no shutdown + Enables serial interface 2
```

Disabling an Interface

An interface can be administratively disabled with the **shutdown** command:

```
XSR(config-if<S2/0>)#shutdown + Disables interface
```

Configuring an Interface

You can configure an interface only after invoking Interface configuration mode. Each interface can be configured with a set of interface-specific commands. If you are unsure which commands are available, type **?** to list them for the particular port. Consider the following sequence of commands to configure a GigabitEthernet interface:

```
XSR#config terminal
XSR(config)#interface gigabitethernet 2
XSR(config-if<G2>)#?
description + Text describing this interface
duplex + Manually set the duplex mode
exit + Quit interface configuration mode
help + Description of the interactive help system
ip + Interface Internet Protocol config commands
loopback + Configure interface for internal loopback
no + Negate a command or set its defaults
shutdown + Shutdown the selected interface
speed + Manually set the line speed
XSR(config-if<F1>)exit + Quit Interface mode
```

Displaying Interface Attributes

You can display the current settings of an interface when in Privileged EXEC or Global configuration mode. For example, type:

```
XSR#show interface fastethernet 1
```

or:

```
XSR(config)#show interface serial 1/0
```

Managing Message Logs

Messages produced by the XSR, whether alarms or events, as well as link state changes for critical ports and a management authentication log, can be routed to various destinations with the **`logging`** command. And by issuing the **`no logging`** command, you can block messages to a site while permitting transmission to others.

For normal operation, you should log only HIGH severity alarms which indicate critical events and those requiring operator intervention. Be aware that the XSR may drop LOW and DEBUG level alarms if the system is too busy to deliver them. The number of dropped messages is displayed by the **`show logging`** command.

Be aware that the DEBUG alarm level is used by maintenance personnel only.

The XSR serves the following logging destinations:

- Syslog (to remote Syslog server over the network)
- Console terminal
- Monitor (up to five CLI sessions via Telnet)
- Buffer (in XSR's memory)
- File on CompactFlash card when *persistent* logging (with respect to power loss) is enabled. This feature is used especially for the firewall (see "Configuring Security on the XSR" on page 16-1 for more information)
- SNMP Trap (async notification by XSR to the SNMP Manager)

Logging Commands

You can log all messages into a particular destination based on the severity level of the message (*high*, *medium*, *low* and *debug*) with the **`logging`** command. Note that entering **`logging medium`** sets that level for all destinations. Also, you can log ACL violations in particular on a per-source per-ACL group basis with the **`access-list log`** command and view them every five minutes. Alternatively, you can display the log when it reaches a specified packet threshold with **`access-list log-update-threshold`**. Generally, you can display your logging configuration with **`show logging`** and show or clear messages in the memory buffer with **`show logging history`** and **`clear logging`** commands, respectively. Be aware that the entire message history is lost when the XSR is powered down.

Refer to Appendix A: *"Alarms/Events, System Limits, and Standard ASCII Table"* on page A-1 for a thorough listing of XSR alarms/events and the *XSR CLI Reference Guide* for command details.

Performing Fault Management

When a software problem causes the XSR's processor to fail, the system captures pertinent data, produces a Fault Report, and restarts the router automatically. The Fault Report is useful in diagnosing the problem because it contains the following data relevant to the failure:

- Cause of processor exception
- Time-stamp
- Contents of processor registers
- Operating system status
- Status of tasks, current task (the crashed task)

- Contents of stacks (task stacks, interrupt stack)
- Status of one special task (packet processor by default)
- Code around the crash program counter
- Task message queues
- Memory management statistics
- Task stack traces for all tasks

The router can store one Fault Report, retaining the first Fault Report in case of multiple failures. It is stored in a special RAM memory area which is preserved if the XSR is rebooted but lost if the router is powered down.

A fault report is also captured in case of a catastrophic watchdog interrupt. Typically, the watchdog timer is reset once per second. If the software fails and 2.6 seconds expire, the watchdog hardware will induce an interrupt which initiates the capture of the fault report. After an additional 2.6 seconds, the CPU is reset and the XSR will warm-boot.

Fault reports can be retrieved from the CLI interface and forwarded to Enterasys Support for analysis.

When the XSR automatically reboots after a crash, the following sample message is logged:

```
<186>May 29 22:20:59 1.1.1.1 PLATF System warm boot from crash
```

Fault Report Commands

The **`show fault-report`** command displays the report. Refer to the *XSR CLI Reference Guide* for more command details. The **`clear fault-report`** command can be used to remove old fault reports and reset the XSR to capture a new one.

Capturing Fault Report Data

Enterasys Networks recommends that you enter the following commands from privileged EXEC mode during capture to assist in analysis and simplify the capture process. The **`clear fault-report`** command should only be executed once you are sure that the text has been completely captured since the data is not recoverable afterwards.

- **`enable`**
- **`terminal Length 0`**
- **`show fault-report`**
- **`show version`**
- **`show logging history`**
- **`clear fault-report`**
- **`terminal length 24`**
- **`disable`**

Using the Real-Time Clock

The XSR's Real-Time Clock (RTC) is employed by other system software modules to time-stamp events, alarms and is useful when no network clock source is accessible. It is normally synchronized with a master clock source over the network using the Simple Network Time Protocol (SNTP) but can also synchronize with the battery-supported RTC chip.

For SNTP configuration, see *Chapter 3: Software Configuration* in the *XSR Getting Started Guide.*

RTC/Network Clock Options

SNTP synchronizes the RTC with a network master clock but if there is no network clock source the RTC clock is used on its own. The RTC maintains the correct time with its battery even when the XSR is powered down.

RTC Commands

The real-time clock can be set with the **`clock set`** command. The universal time can be viewed with **`show clock`** command. To set the SNTP server, use the **`sntp-client server`** command. Refer to the *XSR CLI Reference Guide* for more command details.

Managing the System Configuration

The XSR's system configuration consists of three discrete types which are described below. The configuration can also be reset to the defaults, saved, and uploaded or downloaded in bulk.

- *Factory Default Configuration*: These system parameters are set at the factory. If you make configuration changes and do not save them or the startup configuration file cannot be found, the XSR reverts to factory default parameters. You can manually reset to factory defaults on XSR 1800 Series routers by pressing the reset button at the back of the units. XSR 3000 and 4100 Series routers are not equipped with a reset button but you can restore factory defaults via the CLI as described in the next section.
- *Startup Configuration*: These system settings are used as the current running configuration when you power up or issue the **`reload`** command. The startup configuration is stored in non-volatile (Flash) memory as the **`startup-config`** file. The file contains a version number followed by a series of CLI commands. When the XSR restarts, each CLI command in this file is read and executed.
- *Private Configuration*: The **`private-config`** file contains SNMP v3 related commands. When the XSR restarts, each CLI command in this file is read and executed. The file is updated or created when the running configuration is saved to the startup configuration.
- *Running Configuration*: These system settings, known as **`running-config`**, include a version number followed by accumulated commands from **`startup-config`** and user revisions. Changes made to the configuration are lost if you power cycle or reboot unless you save it to **`startup-config`** using the **`copy`** or **`write`** command.

The XSR validates commands as they are entered and rejects with an error message those commands which are invalid.

Resetting the Configuration to Factory Default

In situations where the XSR has invalid software or a problem booting up, you can reset the router and return it to its factory default settings by accessing Bootrom Monitor Mode. Take these steps:

1. Power up with a serial Com connection.
2. During the first five seconds of system initialization, press **CTRL-C** to enter Bootrom mode.
3. When prompted for a password, enter any characters if you have not previously configured a password. If you have configured a password, enter an incorrect password. In either case, the XSR will produce an error message and prompt you to try again.
4. After trying 5 times to enter the "wrong" password, you are prompted to restore factory defaults.

Refer to the *XSR CLI Reference Guide* and *XSR Getting Started Guide* for more details about Bootrom Monitoring Mode.

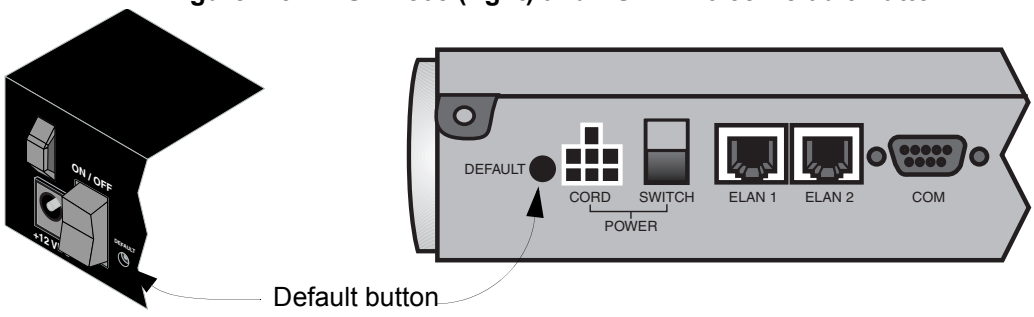
Using the Default Button (XSR 1800/1200 Series Only)

You can also boot up from the factory default configuration by pressing the *default* button on the rear panel of the XSR 1800 and 1200 Series routers. Doing so will erase the content in the startup configuration in Flash memory. After pressing the default button, the XSR performs the following operations:

- Processor is interrupted
- Software enforces default configuration as running configuration
- Software restarts the XSR
- XSR restarts with default configuration
- Original startup configuration in Flash is erased
- Bootrom password is set to default
- Fault report (if any) is cleared
- Security-sensitive files are erased from Flash
- Bootrom Monitor mode network parameters are set to defaults
- Master encryption key is erased from non-volatile memory
- Console connection restarts

Caution: Pressing the Default button erases all files in Flash memory.

Figure 2-3 XSR-1805 (right) and XSR-1220/35 Default Button



Configuration Save Options

There are several options available regarding configuration:

- If you want to make your running configuration the new startup configuration, you can save it to Flash memory with the **`copy running-config startup-config`** command.
- If you want to convert your startup configuration into the running configuration, you can issue the **`reload`** command which reboots the XSR and reloads the startup configuration.
- If you want to save the startup configuration to a remote site using a TFTP server, issue the **`copy startup-config tftp:`** command. See the associated command below.
- If you want to load the configuration manually from a remote site using a TFTP server, issue the **`copy tftp: startup-config`** command. Refer to "Bulk Configuration Management" on page 2-27 for more information about this and the previous command.
- If you want to copy your entire startup configuration including encoded files to a remote site, issue the **`copy flash: full-config tftp:<any_name>`** command when *backing up* the XSR, and the **`copy tftp:<any_name> flash:full-config`** command when *restoring* the XSR. Refer to "Full-config Backup" on page 2-28 for more details about the command.

To view the running-config, use the **`show running-config`** command. To view the **`startup-config`**, issue the **`more startup-config`** command.

For more command details, refer to the *XSR CLI Reference Guide*.

Using File System Commands

A set of MS-DOS compatible commands are available for use in conjunction with configuration files. The XSR has a file system residing in the XSR's non-volatile memory.

You can copy files with the **`copy`** command, remove files with the **`delete`** command, display files with the **`more`** command, verify a packed software image file with the **`verify`** command, and change and list directory contents with the **`cd`** and **`dir`** commands, respectively. For more command details, refer to the *XSR CLI Reference Guide*.

Bulk Configuration Management

The XSR can be configured in one action by storing CLI commands as a script in an ASCII file then transferring the file to the router remotely using TFTP or locally from **`cflash:`**. There is a limitation in the size of the stored file, though. If the file is larger than the limit, then the download operation will abort producing an error message.

Downloading the Configuration

Downloading transfers a script file remotely from a server to the XSR's startup configuration using TFTP or locally from **`cflash:`**. The ASCII-format script can include comments delineated by an exclamation mark.

To perform the task correctly, the TFTP server must be running on a remote device with the configuration file residing in the TFTP *root* directory of the server. You can then enter the **`copy startup-config tftp:`** command in EXEC mode to copy the configuration file from the server to the XSR. *Alternately*, the file must first be loaded in **`cflash:`** then copied to **`flash:`** with the **`copy cflash:startup-config flash:startup-config`** command.

Note: If you have inadvertently added errors to the CLI script file, the restoration of **startup-config** will be stopped at the error line. So, any commands after that line in **startup-config** are not executed.

For more command details, refer to the *XSR CLI Reference Guide*.

Uploading the Configuration/Crash Report

An upload copies the XSR startup-configuration file (partial) to a system in a CLI script format using TFTP. You can later retrieve the file with TFTP.

To perform the task correctly, the TFTP server must be running on a remote device. You then enter the **copy startup-config tftp: <tftp IP addr>/filename** command in EXEC mode to copy the file to the server. A successful upload produces the following sample output:

```
XSR#copy startup-config tftp:
Address of remote host [0.0.0.0]: 10.10.10.10
Destination file name [startup-config]:
Copy 'startup-config' from Flash to server
  as 'startup-config'(y/n) ? y

Upload to server done
File size: 976 bytes
```

You can also upload the crash report via TFTP using the same procedure as the one used to upload the configuration file.

Refer to the *XSR CLI Reference Guide* for more command details.

Full-config Backup

Alternately, you can backup and restore the full configuration file suite including encoded VPN users, usernames, passwords, certificates, and SNMPv3 data files (**user.dat**, **cert.dat**, and **private-config**) to a remote site with a *full configuration backup*. This method employs a modified backup/restore algorithm to copy the data encoded by the master encryption key to the temporary **full-config** file then restores the data in **startup-config** and other data files. Be aware that the same master encryption key is required for both backup (on the source XSR) and restore (on the destination XSR) operations. Information in the **full-config** file is stored either as ASCII text (**startup-config** data) or encrypted binary text (data files).

The **full-config** backup/restore option is also available using SNMP. Refer to "Full Configuration Backup/Restore" on page 2-43 for details.

Creating Alternate Configuration Files

The XSR permits you to create multiple configurations, a useful option if you want to quickly select one of two configuration files stored in **flash:** or **cflash:**, for example: **startup-config** and **startup-configB**. The file named **startup-config** is used by the autoboot process. You can use any file name for the alternate configuration.

To make an alternate configuration file available, rename **startup-config** to **startup-configA** (for example), and **startup-configB** to **startup-config**., using the **rename** command. Then issue the **reload** command to use the new configuration.

Managing the Software Image

The XSR can store more than one software image in Flash.

Creating Alternate Software Image Files

The XSR can create multiple software images, a useful option if you want to quickly select an alternate image. For example, you can create two software image files: **`XSR1805_a.fls`** and **`xsr1805_b.fls`**.

Begin the process by issuing the **`boot system`** command to create a **`boot-config`** file containing the name of your software file. Enter: **`boot system XSR1805_b.fls`**

The **`boot-config`** file contains the file name - **`XSR1805_a.fls`** - used by the autoboot process. By changing the file name *inside* **`boot-config`**, you will boot from the alternate software file in Flash, **`XSR1805_b.fls:`**

Note: If the boot from Flash fails for any reason, the XSR will attempt to copy the specified software file from the network based on the setting in Bootrom mode. Refer to the following section for details.

BootRom Upgrade Choices

Upgrading from Version 2.xx to 3.xx code on the XSR 1800 Series

Because the XSR does not recognize the 3.*x* format, you cannot use the Bootrom Monitor Mode commands **`bu`** and **`bU`** to upgrade the Bootrom from version 2.*x*. You must upgrade from the CLI using the following procedure:

1. With Bootrom version 2.*x* still installed, first upgrade the firmware image to Release 6.0 in the usual manner by copying the **`xsr1800.fls`** file to the **`Flash:`** directory and rebooting.
2. Copy Bootrom version 3.*x* to the **`Flash:`** directory.
3. Enter the following command from the CLI: **`bootrom update btXSR1800_3_x.fls`** where *x* is the current sub-release number. The XSR will automatically reboot and be operable.

Upgrading from Version 1.xx to 2.xx code on the XSR 1800 Series

There are two methods available to upgrade your Bootrom. If you use the Bootrom Update Utility, you will need the **`updateBootrom.fls`** and **`bootromX_xx.fls`** files. For details on using these files to perform a Bootrom upgrade, refer to "Using the Bootrom Update Utility" on page 2-30.

If not using the Bootrom Update Utility, you must perform a two-step procedure to upgrade from 1.xx to 2.xx Bootrom versions due to a file format change and will need the **`bootrom_uncmp.fls`** and **`bootromX_xx1.fls`** files. For details, see "Local Bootrom Upgrade" on page 2-32.

Pre-upgrade Procedures

XSR firmware upgrades are infrequent but if you do so using Bootrom mode, you must:

- Make a DB-9 null modem serial link to a terminal (HyperTerminal, Procomm, et al.) with 9600 bps, 8 bits, 1 stop bit, and no flow control.
- Make an Ethernet connection at the first network interface (located next to the power switch).
- Connect to the FTP (default) or TFTP server on a host PC running with a known user and password. Be sure you can access the latest Bootrom binary file on the host computer, e.g., **`bootrom1_21.fls`**.

- *Optionally*, if you have CompactFlash installed, you can download the firmware file to **cflash:** then perform Step 1 (see below) followed by the **bu** (lower-case **u**) command.
- If you use the Cabletron TFTP/BOOTP Services application, which does not recognize long file names, first shorten the Bootrom file name to 8 characters or less with an extension, before beginning the download (i.e.: **bootnew.fls**). Rename the file after the download.
- Be aware that factory default Flash is limited to 8 Mbytes and if congested may not be able to store a downloaded Bootrom. Delete old firmware or other files before downloading.

Using the Bootrom Update Utility

The Bootrom update utility upgrades the boot flash sectors of the on-board Flash memory. This update tool functions similar to the **bU** command but also can be executed from a Telnet session, allowing Bootrom updates to be performed remotely. The utility runs as a standalone program and can recognize both old (1.x) and new (2.01) versions of the Bootrom file format. After you complete the Bootrom update, the XSR will reboot.

Note that screen-captured XSR text is displayed in `Courier` font. User-required input appears in larger, **bold** `Courier` font.

1. From a remote Telnet session, at a CLI prompt, configure the "boot-config" file to your current software file residing in flash: (the default is **xsr1800.fls**; if your Bootrom version is earlier than 1.16, the default is **xsr1805.fls**). Enter:

```
XSR(config)#boot system xsr1800.fls
xsr1800.fls saved into flash:boot-config
```

2. Exit to EXEC mode and verify this setting by entering: **more boot-config**. Verify at least two MBytes of flash file space is open by entering the **dir** command. If file space is low, delete unnecessary files. The following files are required (**xsr1800.fls** may be replaced by the current software file):

```
XSR-1805#dir
Listing Directory flash:/

size      date         time      name
--------  ------       ------    --------
208       OCT-31-2002  09:34:16   startup-config
3244017   OCT-31-2002  09:32:46   xsr1800.fls
12        OCT-31-2002  09:31:32   boot-config

3,475,456 bytes free
6,727,680 bytes total
```

3. Using TFTP, transfer the latest Bootrom version from the network. The target name must be **bootrom.fls:**

```
– XSR-1805#copy tftp://192.168.27.95/C:/tftpDir/ bootrom2_01.fls
  flash:bootrom.fls

– Copy 'tftpDir/bootrom2_01.fls' from server as 'bootrom.fls' into
  Flash(y/n) ? y

– !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

– Download from server done

– File size: 820136 bytes
```

4. Using TFTP, transfer **updateBootrom.fls** from the network:

```
XSR-1805#copy tftp://192.168.27.95/C:/tftpDir/ updateBootrom.fls
flash:updateBootrom.fls
Copy 'tftpDir/updateBootrom.fls' from server
  as 'updateBootrom.fls' into Flash(y/n) ? y
!!!!!!!!!!!!!!!!!!!!!!!!
Download from server done
File size: 667172 bytes
```

5. Copy **boot-config** to **restore-boot-config**:

```
XSR-1805#copy flash:boot-config flash:restore-boot-config
Copy 'boot-config' from flash: device
  as 'restore-boot-config' into flash: device(y/n) ? y
copying file flash:boot-config -> flash:restore-boot-config
Copy OK: 12 bytes copied
12 bytes copied
```

6. Reconfigure **boot-config** to boot **updateBootrom.fls**:

```
XSR-1805(config)#boot system updateBootrom.fls
updateBootrom.fls saved into flash:boot-config
```

7. Display the current list of files and the contents of **boot-config** and **restore-boot-config** to verify the transfers went smoothly:

```
XSR-1805#dir
Listing Directory flash:/
size              date         time      name
208              OCT-31-2002  09:34:16   startup-config
3244017          OCT-31-2002  09:32:46   xsr1800.fls
820136           OCT-31-2002  09:40:42   bootrom.fls
667172           OCT-31-2002  09:42:06   updateBootrom.fls
18               OCT-31-2002  09:44:10   boot-config
12               OCT-31-2002  09:43:44   restore-boot-config

1,984,512 bytes free
6,727,680 bytes total

XSR-1805#more boot-config
updateBootrom.fls

XSR-1805#more restore-boot-config
xsr1800.fls
```

8. This is a critical step and all previous steps must be completed accurately before proceeding. Reload and wait a couple of minutes. You will lose your Telnet session as the system reboots. The XSR will run **updateBootrom.fls** and update the Bootrom into the boot flash sectors. Power must not be interrupted since a power failure or interruption may render the XSR unusable. The file, **restore-boot-config**, will be renamed to boot-config and **updateBootrom.fls** and **bootrom.fls** will be removed before the router is rebooted again.

```
XSR-1805#reload
Proceed with reload (y/n) ? y
```

9. Verify that the system is up by remotely logging in via Telnet. Enter `show version` and check the new Bootrom version.

Local Bootrom Upgrade

Due to the change in the format of the Bootrom file between version 1.*x* and version 2.01, a transitional step is required when updating across these versions only. This transitional step can be avoided by using the Bootrom Update utility described above.

When you are running a 1.*x* version of the Bootrom and you try to upgrade to version 2.01 of the Bootrom file, it will be rejected due to the change in format. **bootrom_uncmp.fls** is a transitional, non-redundant Bootrom file that the existing 1_*x* version bU command can recognize. By updating and rebooting with this transitional version, you can subsequently use the new **bU** command (which recognizes the new 2.01 format) to update the Bootrom to version 2.01. Be aware that if you boot with **bootrom_uncmp.fls**, you will see the following output on the screen:

"Danger! Cannot find a good copy of Bootrom"

After upgrading to version 2.01 with **bootrom2_01.fls**, you can reboot and all subsequent Bootrom updates (which do not involve a change in the bootFirst module) are power-safe.

In summary, when upgrading 1.*x* to 2.*x* Bootrom versions *only*, you must run the **bU** command twice - first with the **bootrom_uncmp.fls** file, then with the upgraded Bootrom. Between upgrades you must reboot using **bw**.

To upgrade your firmware using the Local Bootrom Upgrade, perform the following steps:

1. Power on the XSR by flipping the rear switch and observe the front LEDs. When the system, VPN, console, NIM1 and NIM2 LEDs turn off, immediately enter **<Ctrl-C>** on the terminal. If you miss this time window, power off and try again. The Bootrom monitor menu should appear as follows:

```
                X-Pedition Security Router Bootrom
Copyright 2003 Enterasys Networks Inc.

HW Version: 9002854-02 REV0A Serial Number: 2854019876543210
CPU: IBM PowerPC 405GP Rev. D
VxWorks version: 5.4
Bootrom version: 1.20
Creation date: Aug 26 2002, 11:16:44

Cold Start: SystemReset from powerup
Password:

Entering ROM monitor Type "h" for help

Using default Bootrom password The system is not secure!!!
Use "bp" to change password

XSR1800:
```

2. Type **h** or **?** to display the command groups.
3. Type **f** to list the file command group.
4. Type **n** to list the network command group.
5. Using the **np** command, assign the following:
   - Local IP address (of the XSR).
   - Remote (host computer) IP address (The host must be on the same subnet as the XSR).

- DOS-style full path (without the file name) of the site of the Bootrom file on the host PC.
- The username and password to use when connecting to your FTP server on the host PC.

6. Verify the network boot values using the **sn** command. For example:

```
XSR: sn
Local IP address  : 192.168.1.1
Remote IP address : 192.168.1.2
Remote file path  : c:/XSR
Transfer Protocol : FTP
Ftp userid        : administrator
Ftp password      : anonymous
Local target name : XSR
Autoboot          : enabled
Quick boot        : no
Current 405 ethernet MAC address is: 00:01:f4:00:01:02
Current PCI ethernet MAC address is: 00:01:f4:01:01:03
```

7. Type **b** to list the boot command group.
8. Enter the **bU** command to transfer the Bootrom image file over FTP and upgrade the Bootrom flash sectors to the latest version. Be sure to enter the command with an uppercase **U** and follow the prompts.

Caution: If the Bootrom file transfer is corrupted due to a network interruption, this step may render the router unusable. If you suspect this has happened, type **n** at the confirmation prompt to abort erasing and replacing the Bootrom. Then, delete the file (type: **rm bootrom1_21.fls**, for example) and re-issue the **bU** command to transfer the image again. Here is a sample session:

```
XSR1800: bU bootrom_uncmp.fls
ftp RETR 192.168.1.2:c:/XSR1850/ bootrom_uncmp.fls into
flash bootrom_uncmp.fls
........ Saved 818448 bytes to flash: bootrom_uncmp.fls

Checking bootrom_uncmp.fls...
Updating bootrom with file, "bootrom_uncmp.fls".
Proceed with erasing current Bootrom in flash and replace with
bootrom_uncmp.fls? (y/n) y

**************************************************
*   Do not interrupt or power down until complete!  *
**************************************************

Erasing 3 sectors at address=0xfff20000
Programming 131072(0x20000) bytes at address 0xfff20000
Programming 131072(0x20000) bytes at address 0xfff40000
Programming 48299(0xbcab) bytes at address 0xfff60000
Verifying Bootrom flash sectors
Locking 3 Bootrom flash sectors

Second copy of Bootrom ...
Erasing 3 sectors at address=0xfff80000
Programming 131072(0x20000) bytes at address 0xfff80000
```

```
Programming 131072(0x20000) bytes at address 0xfffa0000
Programming 48299(0xbcab) bytes at address 0xfffc0000
Verifying Bootrom flash sectors
Locking 3 Bootrom flash sectors
Locking 8 Bootrom flash sectors

*****   Bootrom update completed.   *****

Do you want to remove the bootrom file bootrom_uncmp.fls? (y/n) y

Using default Bootrom password.  The system is not secure!!!
Use "bp" to change password
```

9. Reboot the XSR by entering **bw**.
10. Repeat Step 8 with: **bU bootrom2_01.fls**
11. Reboot the XSR again: **bw**
12. Your Bootrom in Flash memory is now updated and will be used during the next power up sequence.

Note: For more information, consult the SSR boot Release Notes at:
http://www.enterasys.com/download/

Loading Software Images

If the XSR has a valid Bootrom but no valid firmware, the software can be loaded from Bootrom Monitor mode using FTP. You also have the option of copying the image remotely from a TFTP server, using the **copy tftp: flash:** command, or locally from **cflash:**, using the **copy cflash:** command. Be aware that should the transfer fail, the XSR may temporarily be without valid software in **flash:** and should not be reloaded or powered down until a new image is downloaded. Also, the CLI session which initiated the **copy** command is blocked during a TFTP download, with a character repeatedly shown on screen to indicate a file transfer in progress.

Using EOS Fallback to Upgrade the Image

The easy to use Enterasys Operating System (EOS) fallback feature safely upgrades your image, as configured from either the CLI using the **reload** command or via SNMP. If the new image does not successfully install, the XSR will automatically *fall back* to the previous running image. The functionality works as follows: you download a new, *primary* image which the XSR will reboot from. After this image loads, the EOS fallback test will run for a period you configure. The test checks if the XSR crashes, and optionally checks if the configuration causes a syntax error or whether the XSR receives any SNMP messages with the primary image. If successful, the following syslog message is sent:

```
<186>Jun  8 08:49:39 Toronto PLATF: EOS Fallback Test Completed, file
my_new_XSR1800.fls is OK
```

If the test fails, the XSR will send an error message and reboot with the *secondary* image - the last image loaded before the primary image - and will disregard the primary image. Syslog failure messages can cite *no message from SNMP in 30 minutes*, *startup-config error*, *crash* and *watchdog expired*. Respond as follows to these failure causes:

- If XSR reboots with the secondary EOS file, check the fault report generated and retry reload

- If the power to XSR fails, try another reload
- If a syntax error is indicated, examine your configuration for errors
- If XSR crashes, do not retry reloading. Contact Technical Support

EOS fallback is configurable from the CLI or via SNMP. Refer to the following section to configure the feature on the CLI or "Configuring EOS Fallback via SNMP" on page 2-35 for SNMP configuration instructions.

Configuring EOS Fallback on the CLI

1. Upgrade the bootrom. Because EOS fallback is implemented partially in bootrom and partially in the router image, both the bootrom and image must be upgraded. Minimum requirements are as follows on each router type: XSR 1800 Series - bootrom *3.4*, XSR 1200 Series - bootrom *1.1*, XSR 3000 Series - bootrom *1.7*.

   Refer to "BootRom Upgrade Choices" on page 2-29 for directions.

2. Copy the new EOS file to the XSR's Flash or Compact Flash memory as **`flash:xsr1800.fls`** or **`cflash:xsr1800.fls`**. If you do not stipulate the flash directory, the default chosen is *flash:*.

Note: The XSR Series 1800 Flash directory can contain only one image, so you must load the file to *cflash:*. Flash RAM in Series 1200 routers has a 16-Mbyte capacity and can hold two image files.

3. Enter the **`reload fallback primary-file {cflash: | flash:} duration [config | snmp [ip-address]]`** command. For example, type: **`reload fallback cflash:xsr3004.fls 6 config snmp 1.1.1.2`**.

   Refer to the *CLI Reference Guide* for more information on the command.

Configuring EOS Fallback via SNMP

The following procedure configures EOS fallback through the SNMP *Enterasys-image-validation-mib* and *Enterasys-configuration-management-mib*.

Caution: You **must** enable EOS Fallback on the CLI before specifying the primary image and rebooting the XSR. Refer to "Configuring EOS Fallback on the CLI" in the previous section.

1. Enable EOS fallback by setting the *etsysImageValidationEnable* OID in the *Enterasys-Image-Validation-MIB* to **`enabled`**.

2. Configure other parameters in this MIB. For example, set *etsysImageValidationOperations* to **`0xa0`** to enable the *config* and *snmp* tests during EOS fallback verification as follows:

- Enable EOS fallback: **`set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.47.1.1.1.0 1`**
- Set test duration to *10* minutes: **`set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.47.1.1.2.0 10`**
- Set test *config* and *snmp* values: **`set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.47.1.1.3.0 a0`**
- Monitor SNMP requests from the PC with IP address *1.1.1.2*: **`set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.47.1.1.7.0 01010102`**

Note: The *etsysImageValidationOperations* for ping is *not* supported.

3. Add a row to the *Configuration Management Change Table* that specifies the primary image: **`set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.16.2.7.1.11.1 5`**

4. Set the primary file name which include the file (*x*.fls) and device name (flash: or cflash:): **`set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.16.2.7.1.2.1 file://cflash:/xsr3004.fls`**

5. Set the operation to *imageSetSelected*:
   `set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.16.2.7.1.3.1 0100`
6. Set the row to *active*:
   `set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.16.2.7.1.11.1 1`

Note: The primary image **`cflash:xsr3004.fls`** must already exist in the XSR, otherwise the configuration will fail at this point.

7. Reboot the XSR to load the new image by configuring the following:

- Create a row: **`set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.16.2.7.1.11.2 5`**
- Set operation to *resetSoftwareset*: **`1.1.1.1 .1.3.6.1.4.1.5624.1.2.16.2.7.1.3.2 8000`**
- Set the row to active: **`set 1.1.1.1 .1.3.6.1.4.1.5624.1.2.16.2.7.1.11.2 1`**

Note: The *Configuration Management* MIB lets you add a delay (*Etsysconfigmgmtchangedelaytime*) In Steps 3-6 and Step 7. Be aware that the Step 7 delay *cannot* be smaller than the delay set in Steps 3-6.

Downloading with FIPS Security

In compliance with Federal Information Processing Standard (FIPS) security, XSR 1800/3000 Series routers require a different download procedure than usual. You must specify the FIPScompliant

HMAC SHA-1 key using either the Bootrom **key** command or the **sw-verification key** command on the CLI. Follow the prompts as instructed.

When FIPS is enabled, all .FLS files must be signed with the signing utility: **`signEtsFls.exe -k <20hexdigits><xsr1800.fls>`**. Only signed incoming FLS files will be accepted from TFTP, SNMP and CompactFlash. After FIPS is enabled, back revisioning is not permitted. To disable FIPS, press the Default button (on the XSR 1800 Series) to clear all configuration settings including the FIPS and master encryption keys.

For the XSR 3000 Series only, FIPS can be disabled by entering five invalid Bootrom password entries. You will be prompted before the XSR reverts to the default factory configuration and clears the FIPS key.

Software Image Commands

You can view the status of the software image including such data as the current firmware *image filename*, software release *version*, *timestamp*, and *size* by issuing the **`show version`** command.

Use the **`boot system`** command to actively change the default file name of the software image.

For more command details, refer to the *XSR CLI Reference Guide*.

Configuration Change Hashing

Transparently, the XSR hashes persistent configuration changes and stores them in an SNMP accessible variable to assist you in assessing remote backups or device monitoring. Hashing by the MD5 algorithm is conducted on the following files:

- **`startup-config`**
- **`private-config`**
- **`user.dat`**

When the XSR boots up, the checksum of these files is calculated and stored in volatile memory. From then on any time the content of those files is changed the hash is recalculated and stored. You can access the hash value in the *etsysConfigMgmtPersistentStorageChSum* SNMP object and compare it with previous queries to detect configuration changes to the managed entity.

Displaying System Status and Statistics

The XSR's numerous **`show`** commands, which are available in either privileged EXEC or Global configuration mode, display a broad array of system data such as:

- System name, port types and their status, CPU card revision, Flash memory and DRAM size, NIM cards and type, contact and system hardware data, image in Flash, and system location.
- XSR statistics: buffer counters, packets and NIM card status.

To display available show commands, issue the **`show ?`** command.

Some system data such as the product type and serial number, hardware revision number of the motherboard, and Ethernet port MAC addresses is stored in IDROM, a discrete area in Flash memory. You can view these parameters by issuing the **`show version`** command.

Refer to the *XSR CLI Reference Guide* for details about these commands.

Memory Management

The XSR provides memory management via its Resource Capacity feature. Resource Capacity marks an advance in flexibility over the hard-coded limits mechanism of earlier releases in that you can now choose which software modules to configure based on available memory per resource. Resource Capacity is designed to control resource creation so that the XSR does not run out of memory and operate improperly.

The XSR defines a *resource* as a software element which can be created or deleted in run time. When it is created it allocates memory by calling the memory management *malloc* function. When deleted, it returns the memory to common pools by calling free functions. Currently, approximately 45 resources including VPN tunnel, Access List entry, Route, and ARP request are tracked by a memory governor which can be accessed with the **`show resources`** command.

A resource can exist multiple times - for example, 5000 VPN tunnels - and each occurrence is considered an *Instance* by Resource Capacity. The maximum number of resource instances which can be created in a situation where practically no other resource is present constitutes that resource's *Extreme Limit* although it is highly unlikely you will ever configure that many instances. Extreme limits are hard-coded, they can not be configured, and their size depends on the total amount of installed memory on the XSR.

Creating Resources

You can create a new instance of a given resource depending on the extreme limit for that resource and the current amount of available memory. Because you can keep creating resources until you run out of memory, you should find the right balance to satisfy your system operational needs - the XSR does not arbitrarily limit any particular resource.

For example, you may want to create a "VPN-heavy" configuration with many VPN tunnels, but only a few routes. In this case, the number of tunnels is not limited as it was in earlier releases. Alternatively, you can set up a "route-heavy" configuration with many routes but only a few tunnels. In either case, memory usage is balanced.

When the memory governor is asked to allow or deny a new resource, the decision is based on:

- memory low watermark
- extreme limit

You can push the extreme limit of individual resources as long as the memory low watermark is not met. Once the low watermark is met and you wish to create more resources, you must then free up earlier configured resources.

The memory low watermark can constrain resource creation as follows:

- Un-carved (un-allocated) memory remains in the memory "pie". If un-carved memory is lesser than a given number (e.g., 1 Mbyte) creation is denied but if it is larger, it is permitted.
- All memory has been carved. Each free pool (64-byte, 128-byte, and others) must have at least the defined number of blocks to permit resource creation.

The XSR manages memory more efficiently by means of different-sized memory blocks. Memory is carved during run time based on malloc requests received. Depending on your startup configuration, memory will be carved in different ways. There are more than 10 fixed-size pools, with the amount of carved buffers in each pool depending on your startup configuration. You can examine memory buffering with the **`show buffers`**, **`show buffers malloc`**, and **`show buffers i/o`** commands.

If you intend to configure and un-configure a large number of resources, be advised to reboot the XSR when necessary to optimize memory carving.

Also remember that resource creation will be denied in the highly unlikely event of an extreme limit being reached.

Caution: Do not enroll more certificates nor add more AAA users than permitted by the 1.5 MByte system limit imposed on both Flash **`cert.dat`** and **`user.dat`** files, respectively. Doing so may disable the XSR and require you to delete the files.

Network Management through SNMP

XSR system monitoring provides for the SNMP v1 agent (READ-ONLY) including gets and limited sets and SNMP v3 gets and sets. Standard MIB II modules are supported as well as Enterasys MIBs, as listed in the following table. Proprietary MIBs are available via download at: **`http://www.enterasys.com/support/mibs`** For a list of supported proprietary and standard MIB objects, refer to the table in "Chapter 1: Network Management "of the *XSR User Guide.*

In order to use SNMP to gather statistics or configure the device, first configure the XSR's SNMP agent with the **`snmp-server`** commands.

Variables you can set are: *community name, traps, informs* and *host*. SNMP v3 support includes options to specify an *engineID*, security values for *users* and *groups*, and associated **`show`** commands. The **`snmp-server view`** command is an especially powerful tool to display SNMP objects either via their SNMP term or numerical ID. SNMP v3 data is stored in the **`private-config`** file in Flash. Although SNMP is disabled by default, entering any SNMP configuration command except **`snmp-server disable`** will enable the server.

Refer to "XSR SNMP Proprietary and Associated Standard MIBs" on page B-1 for more information about supported tables and table objects.

SNMP Informs

SNMP Informs were first introduced in SNMPv2. An Inform is essentially nothing more than an acknowledged *trap*. That is, when a remote application receives an Inform it sends back an "I got it" message. When you send an Inform you use the remote *engineID* with the message and the *securityName* and *engineID* exist as a pair in the Remote User table. The SNMP trap program discovers the remote engineID as other applications would and creates the SNMPv3 message with the proper user that the remote side is expecting to receive.

SNMP v3 on the XSR is supported by several CLI and SNMP agent enhancements. SNMP v1/v2c traps can be configured with remote IP addresses to send traps with the **`snmp-server host`** command. For SNMP v3, each agent has a unique identifier - the engine ID - which is used to configure users in the User Security Model (USM). With the SNMP v3 USM, the XSR requires configuration of remote engine IDs and remote users.

To set up an inform recipient, first set the engine ID of the remote SNMP entity with **`snmp-server engineID`**. USM users may then be added with **`snmp-server user`**. Complete the configuration using **`snmp-server host`** to specify remote SNMP entities that will receive informs. The **`snmp-server informs`** command can be used to change the global retry, timeout and queue default settings. The **`snmp-server enable traps`** command remains the same in all SNMP versions. This command enables both traps and informs.

For a full description of SNMP commands, refer to the *XSR CLI Reference Guide*. Also refer to NetSight Atlas Router Services Manager v2.0 documentation to query and change SNMP values. Because the SNMP manager is disabled at boot-up, you must either manually enable the SNMP manager using the CLI, or enable it in **`startup-config`**.

Shaping Trap Traffic

Two controls are available to manage network traffic caused by SNMP traps. The first, set by the **`snmp-server min-trap-spacing`** command, configures minimum spacing between successive traps to ensure that they are spaced without causing delay and cap the number of packets generated by traps.

The second control defines the maximum number of traps that can be sent in a given time window. The time window is a moving sum of the number of traps sent to the network. If the number of traps sent in the previous window-time is less than the value set by the **`snmp-server max-traps-per-window`** command, then more traps can be sent.

Both methods work simultaneously and independently and only when both are satisfied will a trap be sent. Otherwise, traps will be queued and sent as soon as conditions satisfy both traffic shaping methods.

Statistics

The XSR supports SNMP *gets* for MIBs listed in "Chapter 1: Network Management "of the *XSR CLI Reference Guide.* Also, refer to NetSight Atlas Router Services Manager v2.0 to query and change SNMP values.

Alarm Management (Traps)

The following events are supported by SNMP traps: *snmpTrapColdStart*, *snmpTrapWarmStart*, *snmpTrapLinkDown*, *snmpTrapLinkUp*, *snmpTrapAuthFailure*, *entityTrapConfigChange*, *frameRelayTrapfrDLCIStatusChange*, *ospfTrapIfStateChange*, *ospfTrapVirtIfStateChange*, *ospfTrapNbrStateChange*, *ospfTrapVirtNbrStateChange*, *ospfTrapIfConfigError*, *ospfTrapVirtIfConfigError*, *ospfTrapIfAuthFailure*, *ospfTrapVirtIfAuthFailure*, *ospfTrapIfRxBadPacket*, *ospfTrapVirtIfRxBadPacket*, *ospfTrapTxRetransmit*, *ospfTrapVirtIfTxRetransmit*, *ospfTrapOriginateLsa*, *ospfTrapMaxAgeLsa*, *ospfTrapLsdbOverflow*, *ospfTrapLsdbApproachingOverflow*, *bgpTrapEstablished*, and *bgpTrapBackwardTransition*.

SNMP alarms are listed in Appendix A: "Alarms/Events, System Limits, and Standard ASCII Table" on page A-1.

Network Monitoring via Service Level Agreement Agent

The XSR supports a Service Level Agreement (SLA) agent to monitor network performance based on configurable latency, jitter, and packet loss metrics as well as to query the results. You can schedule measurements between the XSR and any remote host which supports the type of operation - ICMP echo - used to perform the measurement.

There are two management interfaces which operators can choose from to perform monitoring: *CLI* or *SNMP*. The SLA agent supported via the CLI is based on the de facto industry standard whereas the supported MIB provided by the SNMP interface is based on the *Enterasys-Service-Level-Reporting-MIB* (SLR). This MIB in turn is based on the *IP Performance Monitoring Reporting MIB*, now in RFC draft form.

The SLR MIB classifies network performance by network and aggregate measurements as follows:

- *Network* measure - Performs several metric measurements per packet exchange: each measurement step produces a single result per metric.
- *Aggregate* measure - Summarizes the results of previous network or aggregated measurements.

For example, metrics such as *packet loss* and *round-trip delay* are classified as network measurements while *round-trip delay average* and *jitter* metrics, which are calculated based on previous results, are classified as aggregate measurements. This is described further in the following sections.

Note: The SLA agent provides statistics based on *round-trip* measurements only and includes XSR processing time.

For more information on SLA-related CLI commands, refer to the *XSR CLI Reference Guide*. Refer to Appendix: B "Service Level Reporting MIB Tables" on page B-1 for a list of XSR-supported fields and tables from the *Enterasys Service Level Reporting MIB*.

Measuring Performance Metrics

XSR performance metrics are measured as follows:

- *D(i)* - the value for the *i*th measurement
- *Ri* - receive time for the *i*th measurement
- *Si* - sending time for the *i*th measurement

Latency (network delay) is measured with the formula: *D(i)=(Ri-Si)*, which is the round-trip interval between sending and receiving the ICMP packet triggered by the initiator and echoed back by the target.

Jitter (network delay variation) is the value between packets *i* and *j* as figured by the formula: *D(i,j)=(Rj-Ri)-(Sj-Si)*. Since the XSR measures the round trip, *Ri* indicates the receive interval at the source instead of the target.

Packet loss - If an ICMP echo reply packet is not received within a specified time, it is considered lost. This does not allow the operator to identify whether the packet is lost on the way to the target or when the response is traveled from the target back to the sender.

Configuration Examples

The following CLI and SNMP examples illustrate how to create: an *owner*, a *measurement to ping*, *schedule a measurement*, and *query a measurement*.

Create an Owner

The XSR provides a default owner *monitor* residing in the first row of the owner table. If you want to create another RTR owner, follow the instructions below.

Via CLI

The following example creates the user *Clem*:

```
XSR(config)#rtr owner Clem
```

Via SNMP

The example below creates a user in row 2 of the table (the instance is 2 as indicated in bold):

1. Create a row (*etsysSrvcLvlOwnersStatus*):
   `1.3.6.1.4.1.5624.1.2.39.1.2.1.1.9.2 = 5 (createAndWait)`
2. Configure user (*etsysSrvcLvlOwnersOwner*):
   `1.3.6.1.4.1.5624.1.2.39.1.2.1.1.2.2 = userA`
3. Change the row status to active (*etsysSrvcLvlOwnersStatus*):
   `1.3.6.1.4.1.5624.1.2.39.1.2.1.1.9.2 = 1 (active)`

Note: The string *userA* is equivalent to the ASCII value *117:115:101:114:65*, which will be used to index into the aggregate measure table. If you want to use the default owner, the ASCII value of the default owner (*monitor*) is *109:111:110:105:116:111:114*.

Refer to "Standard ASCII Character Table" on page A-19 for more information. With NetSight Atlas MIB Tools, retrieve the ASCII value from the Raw Value column, as shown in Figure 2-4.

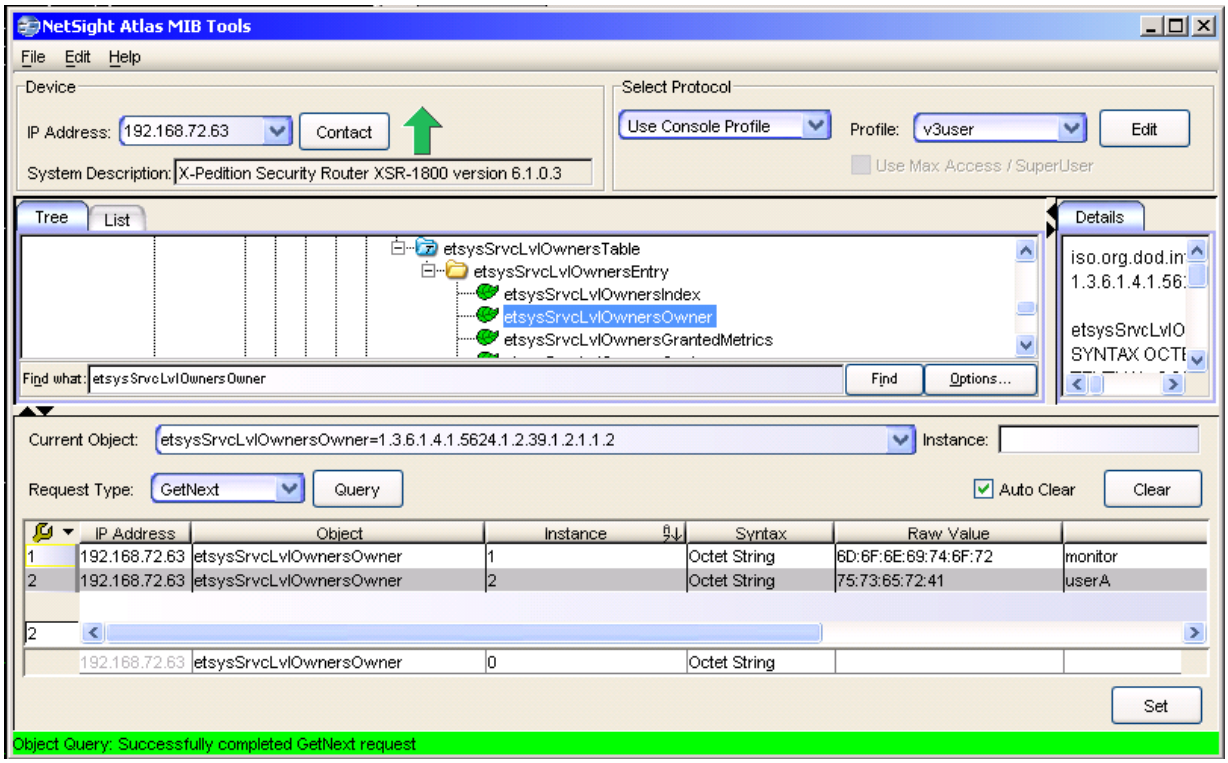
Figure 2-4 NetSight Atlas MIB Tools Screen

Create a Measurement to Ping

Via CLI

The following example adds a ping measurement to IP address *1.1.1.1*:

```
XSR(config)#rtr 1
XSR(config-rtr-echo-1)#type echo protocol ipIcmpEcho 1.1.1.1
```



Via SNMP

The following example creates a row in the aggregate measure table with owner *userA*. If the entry is created with owner *monitor*, replace *5.117.115.101.114.65* with *7.109.111.110.105.116.111.114*.

1. Create a row (*etsysSrvcLvlAggrMeasureStatus*):

```
1.3.6.1.4.1.5624.1.2.39.1.4.2.1.18.5.117.115.101.114.65.1 = 5 (createAndWait)
```

2. Configure the destination address (*etsysSrvcLvlNetMeasureDst*) in the network measure table:

```
1.3.6.1.4.1.5624.1.2.39.1.4.1.1.14.5.117.115.101.114.65.1 = 1.1.1.1
```

Schedule a measurement

Via CLI

The following command schedules a measurement immediately:

```
XSR(config)#rtr schedule 1 start-time now
```

Via SNMP

1. The following example obtains the current time by querying the *etsysSrvcLvlSystemTime* schedule a measure (*1.3.6.1.4.1.5624.1.2.39.1.1.1.0*).
2. Configure the measurement begin time (*etsysSrvcLvlAggrMeasureBeginTime*) to *now* which is the result of the above query:

```
1.3.6.1.4.1.5624.1.2.39.1.4.2.1.5.5.117.115.101.114.65.1 =  0796BD1048F5C28F
```

3. Change the row status (*etsysSrvcLvlAggrMeasureStatus*) to *active* and activate the measure:

```
1.3.6.1.4.1.5624.1.2.39.1.4.2.1.18.5.117.115.101.114.65.1 = 1
```

Query a Measurement

Now that you have performed the previous actions, you can query the measurement result.

Via CLI

The following command displays *rtr* output:

```
XSR#show rtr history
```

Via SNMP

1. Query the *etsysSrvcLvlHistoryTable* (*1.3.6.1.4.1.5624.1.2.39.1.3.1*).

Using the SLA Agent in SNMP

The XSR's SLA agent implements the Enterasys Service Level Reporting MIB and supported metrics as detailed in the following tables, which may cross-reference each other. For example, *etsysSrvcLvlNetMeasureIndex* is used to index *etsysSrvcLvlHistoryTable* as well.

Note: All configurable values are limited by ranges specified in the CLI.

Refer to Appendix B: "Service Level Reporting MIB Tables" on page B-1 for supported OIDs.

Full Configuration Backup/Restore

The XSR supports a full configuration backup and restore via SNMP using the *Enterasys Configuration Management* and *Cabletron CTdownload* MIBs. Follow the steps below.

Cabletron CTdownload MIB

1. Select the *downLoadConfiguration(4)* and *upLoadConfiguration(5)* operations in the *ctDLOnLineDownload* field.
2. Specify the address of the TFTP server in *ctDLNetaddress*. Start the transfer with the appropriate value in *ctDLOnLineDownload*. Monitor the transfer's progress by polling the *ctDLOperStatus* field. Note that by definition, the XSR will be reset after a **`full-config`** is downloaded, unbundled, verified and committed to RAM.
3. During an upload of **`full-config`**, the **`user.dat`**, **`cert.dat`**, and **`private-config`** files will be bundled and stored in a temporary file (**`full-config`**), then uploaded to the TFTP server.

Enterasys Configuration Management MIB

1. Select the *configurationUpload(5)* and *configurationDownload(6)* operations in the *etsysConfigMgmtChangeOperation* field. Specify the file name as *full-config*.
2. In order to activate the configuration, the *configurationActivate(9)* command is issued causing a bundled **`full-config`** to be unbundled and become the active (**`startup`**) configuration. The file name in *etsysConfigMgmtChangeURL* must indicate **`full-config`**. This action initiates a system reset.
3. The upload and download of the **`startup-config`** file follows the same steps as in the Cabletron MIB but does not bundle or unbundle other configuration components.

Software Image Download using NetSight

The NetSight Remote Administrator application can download an image to the XSR using TFTP. The software image download is initiated through NetSight using an SNMP **`set`** command, which triggers a TFTP download session initiated from the XSR.

Note: The XSR does not support an off-line download triggered by SNMP. That is, when you use NetSight to download an image, a dialog box will pop up with a check box titled *Online download*. If the box is unchecked, the SNMP request will fail. See NetSight documentation for more information.

SNMP Download with Auto-Reboot Option

To use this option, you must first enter the following command in Global mode to allow a user to reboot the XSR using SNMP:

```
XSR(config)#snmp-server system-shutdown
```

When you employ NetSight to download an image, a dialog box will pop up with a check box titled *Auto reboot*. If the box is checked, the XSR will be rebooted remotely after the download ends. If the **`snmp-server system-shutdown`** command were not entered and the remote user chose the auto reboot option, the request would fail.

CLI Translator

The XSR provides a CLI Translator as a stand-alone CLI configuration application or a NetSight plug-in application to translate a CLI script configuration file, which can be downloaded to the XSR through TFTP.

Appending CLI Commands to Configuration Files via SNMP

The XSR permits appending a file containing CLI commands to your configuration by using SNMP. This is done by the *ConfigurationAppend* command in the *Configuration Management MIB* executing CLI commands. In detail, it is performed as follows:

- Using TFTP, the file is copied to the XSR's **`Flash:`** directory using a temporary file name. If an error occurs while transferring the file, an error message will be sent to the SNMP agent and displayed in the *etsConfigMgmtChangeErrorDescription* field.
- Once the file has successfully transferred, the ConfigurationAppend command acquires Global mode and begins reading the CLI commands from the file. If Global mode is locked by another user then an error will be displayed in the *etsConfigMgmtChangeErrorDescription* field and the temporary file deleted.
- When all command lines have been executed the SNMP agent is informed that the command was successful. If an error occured in the file, you are informed through the SNMP agent.
- The running configuration is saved to the startup configuration on the CLI.
- The SNMP user is informed that the command was successful and the temporary file name is then deleted.

Follow the steps below to perform the append:

Note: Before starting this procedure, make sure that a TFTP server program is running on your PC.

1. Write a plain ASCII file containing the CLI commands you want entered. For example:
   ```
   interface FastEthernet2
   ip address 192.168.19.1 255.255.255.0
   no shutdown
   ```
2. Save and move the file to the *root directory* of the TFTP server on your PC.
3. Use SNMPv3 to create a row in the *Configuration Management MIB*. For example, *CreateAndWait*:
   ```
   1.3.6.1.4.1.5624.1.2.16.2.7.1.11.1 = 5
   ```
   If you read the table, one row should be added.
4. Set the file name to point to the file on your PC:
   ```
   1.3.6.1.4.1.5624.1.2.16.2.7.1.2.1 = tftp://1.1.1.1/newCmd
   ```
5. Set the operation to *configAppend*:
   ```
   1.3.6.1.4.1.5624.1.2.16.2.7.1.3.1 = 0x0020
   ```
6. Set the row to active state:
   ```
   1.3.6.1.4.1.5624.1.2.16.2.7.1.11.1 - 1
   ```
   The configuration in the **newCmd** file is now part of the **running-config**. That is, you will see the configuration for *fastethernet2* when you enter the **show running-config** command.

Note: Be aware that the *ConfigurationAppend* command does not check for syntax errors in the file being downloaded from the server.

For more information, refer to the *Enterasys Configuration Management MIB*.

Accessing the XSR Through the Web

The XSR via a browser but provide a cursory display of hardware configuration data to diagnose the router over the Web. Because the Web server is disabled at boot-up, you must either manually enable the Web server using the CLI, or enable it in **`startup-config`**. The default Web server port is 80. Access to the XSR through the Web is not password protected.

Network Management Tools

The following tools are useful to manage the XSR over the network.

NetSight Atlas Router Services Manager v2.0

XSR firewall and Access Control List (ACL) configuration can performed on the NetSight Atlas Router Services Manager v2.0 application. For more information, refer to the following URL:
http://www.enterasys.com/products/management/NSA-RSM-CD/

For NetSight Atlas documentation, refer to the following URL:
http://www.enterasys.com/support/manuals/netsight.html

Firmware Upgrade Procedures

A variety of tools provided by the XSR and Enterasys' NetSight application support:

Using the CLI for Downloads

TFTP can be used to transfer system firmware to the XSR remotely. A TFTP server must be running on the remote machine and the firmware image file **must** reside in the TFTP root directory of the server when using the **`copy tftp`** *`filename`* command.

Using SNMP for Downloads

You can use an SNMP manager to download or upload firmware from a remote server, and copy a configuration image file to the XSR. Only run-time/online mode downloads are supported. This requires setting the *ctDLNetAddress* and *ctDLFileName* objects and issuing a *ctDLOnLineDownLoad* defined in the CTRON-DOWNLOAD-MIB. For more details click on the following URL: http://www.enterasys.com/support/mibs

Fault Reporting

A fault report can be uploaded through TFTP. The mechanism to upload the crash report is the same as the one used to upload configuration file. Refer to "Performing Fault Management" on page 2-23 for more information.

Auto-discovery

The NetSight Gateway Management Tool can auto-discover an XSR on the network using SNMP with the following MIB variables:

- SysDesr
- SysObjID
- Sysuptime

NetSight also performs auto-discovery via ping using ICMP ping.

3

Managing LAN/WAN Interfaces

Overview of LAN Interfaces

The XSR supports two 10/100 Base-T FastEthernet ports on the XSR 1800 Series branch routers and three 10/100/1000 Base-T GigabitEthernet ports on the XSR 3000 Series regional routers. All ports are capable of running in half- and full-duplex modes, and are ANSI/IEEE 802.3 and ANSI/IEEE 802.3u compliant. These ports connect to an Ethernet network for LAN connectivity.

The Fast/GigabitEthernet interfaces perform the following functions:

- Allow the XSR to connect to networks of speeds of 10 Mbps, 100 Mbps, or 1000 Mbps (using manual settings or auto-negotiation)
- Monitor the status of the link: up or down
- Allow you to issue interface/device configuration commands through the Command Line Interface (CLI)
- Accumulate MIB-II (RFC-1213) interface statistics regarding the transmission and reception of bytes and packets

LAN Features

The XSR supports the following LAN interface features:

- Alarms/events - For a complete list, refer to "Alarms/Events, System Limits, and Standard ASCII Table" on page A-1 in this manual.
- Duplex mode is set using the **`duplex`** command with the following options:
  - *Half* - half-duplex
  - *Full* - full-duplex
  - *Auto* - auto-negotiation (default)
- Packet filtering - the interface will receive:
  - All broadcast packets
  - All multicast packets
  - Unicast packets which have the MAC addresses of the device
- Maximum Receive Unit (MRU) - all frames less than or equal to 1518 bytes are accepted including the 4-byte FCS.
- Oversized packets greater than 1518 bytes are not accepted.
- Runt packets of 64 bytes or less are not accepted.

- Maximum Transmission Unit (MTU) - all frames less than or equal to 1518 bytes are accepted. MTU size is set using the **ip mtu** command.
- Speed is enabled using the **speed** command with the following options:
  - *10* - 10 Mbps
  - *100* - 100 Mbps
  - *1000* - 1000 Mbps
  - *Auto* - Auto-negotiate (default)
- Statistics - all MIB-II interface statistics are supported
- Clear commands such as **clear counters FastEthernet** and **clear counters gigabitethernet**, which reset the MIB-II counters, and **clear interface FastEthernet** and **clear interface GigabitEthernet**, which reset the interface counters and facilitate interface troubleshooting.

Configuring the LAN

Enter the following commands to configure FastEthernet interface 1 on network 192.57.99.32:

```
XSR(config)#interface fastethernet 1
XSR(config-if<F1>)#ip address 192.57.99.32 255.255.255.0
XSR(config-if<F1>)#no shutdown
```

Enter the following commands to configure GigabitEthernet interface 2 on network 192.168.57.12:

```
XSR(config)#interface gigabitethernet 2
XSR(config-if<G2>)#ip address 192.168.57.12 255.255.255.0
XSR(config-if<G2>)#no shutdown
```

MIB Statistics

The following table reflects MIB-II (RFC-1213) port statistics collected by a LAN interface.

Table 3-1 MIB-II Interface Statistics

Variable	Description
IfDescr	Description of the interface.
IfType	Type of the interface (set once, and never changed).
IfMtu	Size of the largest packet that can be sent/received on the interface, specified in bytes.
IfSpeed	Estimate of the interface's current bandwidth in kilobits per second (10000 or 100000)
IfPhysAddress	Interface's address at its protocol sub-layer (the MAC address).
ifAdminStatus	Desired state for the interface.
ifOperStatus	Current operational status of the interface.
ifLastChange	Value of sysUpTime when the interface entered its current operational state.
IfInOctets	Sum of octets received on the interface.
ifInUcastPkts	Sum of subnetwork-unicast packets delivered to a higher layer protocol.

Table 3-1 MIB-II Interface Statistics (continued)

Variable	Description
ifInNUcastPkts	Sum of non-unicast packets delivered to a higher layer protocol.
IfInDiscards	Sum of inbound packets discarded.
IfInErrors	Sum of inbound packets that contained errors.
IfOutOctets	Sum of octets transmitted on the interface
ifOutUcastPkts	Sum of subnetwork-unicast packets sent to the network.
ifOutNUcastPkts	Sum of non-unicast packets transmitted to the network.
IfOutErrors	Sum of outbound packets that could not be sent due to errors.
IfOutDiscards	Sum of outbound packets discarded.

Overview of WAN Interfaces

The XSR supports as many as six serial cards (in an XSR-3250), each of which can support four ports for a maximum of 24 serial ports. Each port is individually configurable regarding speed, media-type, and protocol.

The Serial WAN interface performs the following functions:

- Transmit packets given by the protocol layer onto a serial link.
- Receive packets from a serial link and pass up to the protocol layer.
- Allow CLI configuration commands to be issued.
- Accumulate all MIB-II (RFC-1213) interface statistics regarding the transmission and reception of bytes and packets.

WAN Features

The XSR supports the following WAN interface features:

- *Alarms/events* - For a complete list, refer to "Alarms/Events, System Limits, and Standard ASCII Table" on page A-1 in this manual.
- *Interfaces* - The following interface types can be configured using the **`media-type`** command:
  - *RS232* (also known as V.28) (default)
  - *RS422* (also known as RS-530)
  - *RS449* (also known as V.36)
  - RS530A
  - V.35
  - X.21
- Either *Sync* or *Async mode* is set by using **`physical-layer`**.
- *Encoding* - On Sync interfaces, **`nrzi-encoding`** sets NRZI encoding (NRZ encoding is the default).

- *Clocking speed* - For Sync interfaces, an external clock must be provided. Acceptable clock values range from 2400 Hz to 10 MHz. For Async interfaces, the clock is internally generated and can be set to the following values using **`clock rate`**:
  - 2400 Kbps
  - 4800 Kbps
  - 7200 Kbps
  - 9600 Kbps (default)
  - 14400 Kbps
  - 19200 Kbps
  - 28800 Kbps
  - 38400 Kbps
  - 57600 Kbps
  - 115200 Kbps
- *Statistics* - all MIB-II interface statistics are supported.
- *Clear* commands such as **`clear counters serial`** and **`clear interface serial`** facilitate interface troubleshooting.
- *Async mode commands* such as **`databits`**, **`stopbits`**, and **`parity`** provide configuration of the serial line.
- Maximum Receive Unit (*MRU*) is 1518 bytes (including CRC).

Configuring the WAN

Enter the following commands to configure either a synchronous T1 or asynchronous Serial interface. For more detailed information on the commands used here, refer to the *XSR CLI Reference Guide* and other chapters in this manual.

The following example configures the synchronous T1 controller on NIM 1, port 0 named *Acme T1* with the default values of *ESF* framing and *B8ZS* line encoding. It also specifies channel group 1 with mapped timeslots *1-5, 8* and *9*, assigns the local IP address *192.168.1.1* to the channel group and sets *PPP* encapsulation.

```
XSR(config)#controller t1 1/0
XSR(config-controller<T1/0>)#description T1 "Acme T1"
XSR(config-controller<T1/0>)#framing esf
XSR(config-controller<T11/0>)#linecode b8zs
XSR(config-controller<T11/0>)#channel-group 1 timeslots 1-5,8,9
XSR(config-controller<T11/0>)#no shutdown
XSR(config)#interface serial 1/0:1
XSR(config-if<S1/0:1>)#ip address 192.168.1.1 255.255.255.0
XSR(config-if<S1/0:1>)#encapsulation ppp
XSR(config-if<S1/0:1>)#no shutdown
```

The following example configures the asynchronous serial interface on NIM 2, port 0 with the following non-default values: *PPP* encapsulation, *RS422* cabling, *57600* bps clock rate, MTU size of *1200* bytes, *no* parity, *7* databits and *2* stopbits. It also assigns the local IP address *192.168.1.1* to the interface. Although the XSR is not designed to be an access server, you can attach an external modem to the serial port and accept async calls as long as the modem is configured in "dumb mode" (AT commands are disabled).

```
XSR(config)#interface serial 2/0
XSR(config-if<S2/0>)#ip address 192.168.1.1 255.255.255.0
XSR(config-if<S2/0>)#encapsulation ppp
XSR(config-if<S2/0>)#physical-layer async
XSR(config-if<S2/0>)#media-type rs422
XSR(config-if<S2/0>)#clock rate 57600
XSR(config-if<S2/0>)#ip mtu 1200
XSR(config-if<S2/0>)#parity none
XSR(config-if<S2/0>)#databits 7
XSR(config-if<S2/0>)#stopbits 2
XSR(config-if<S2/0>)#no shutdown
```

The following example configures the XSR to dial-out (async):

```
XSR(config)#interface serial 1/0
XSR(config-if<S2/0>)#encapsulation ppp
XSR(config-if<S2/0>)#physical-layer async
XSR(config-if<S2/0>)#dialer pool-member 1
XSR(config-if<S2/0>)#clock rate 57600
XSR(config-if<S2/0>)#no shutdown

XSR(config-if<S2/0>)#interface dialer1
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer string 015081234567
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 192.168.1.2 255.255.255.0
XSR(config-if<D1>)#no shutdown
```

4

Configuring T1/E1 & T3/E3 Interfaces

Overview

The XSR provides Frame Relay and PPP service via T1/E1 and T3/E3 functionality as well as Drop and Insert features.

T1/E1 Functionality

The XSR provides a T1/E1 subsystem on a single NIM-based I/O card with a maximum of two installed NIMs. Depending on the card type and series, each card can support 1, 2 or 4 T1 or E1 physical ports.

You can select either T1, at 1.544 Mbps interface rate per port, or E1, at 2.048 Mbps interface rate per port. In both operational modes, the interface can work either in *full* rate T1/E1 mode (the complete available line interface rate is assigned to one user), *fractional* T1/E1 mode (only one channel group is assigned, with less than the total available number of timeslots on a T1/E1 line configured per physical port) or in *channelized* mode (more than one channel group is configured per physical port).

In fractional/channelized mode, up to 31 DS0 channels can be assigned on E1 interfaces and up to 24 DS0 channels can be assigned on T1 interfaces. The rate (line speed) of basic channel (DS0) can be configured at 56 or 64 Kbps.

T3/E3 Functionality

The XSR T3/E3 subsystem offers a NIM-based I/O card with a single port, full rate unchannelized T3/E3 mode and sub-rate support for proprietary T3 and E3 DSU vendors. “Sub-rate T3/E3” and “fractional T3” are interchangeable terms describing un-channelized T3/E3 service that delivers less than full line bandwidth.

T3 or E3 mode is software selectable - one hardware NIM supports both modes.

Features

T1/E1 Mode

The following features are offered on the T1/E1 interfaces:

- Integrated CSU/DSU
- Full-rate, channelized and fractional
- Short and long haul symmetrical line interfaces with 100/120 ohm impedance using RJ-45/48C or 49C connectors

- Support for local and remote loopback
- Support for an IP interface as a loopback (refer to the *CLI Reference Guide* for an example)
- Timing - line and internal
- Framing - T1: SF, ESF; E1: CRC4, NO-CRC4
- Line encoding - T1: AMI, B8ZS; E1: AMI, HDB3
- Data inversion
- Loopback Tests - local, network line, network payload, inband FDL
- Alarm detection - all levels of alarm/event detection and signaling
- T1 Drop and Insert (D&I NIM) with One to One voice DS0 bypassing

The following features are offered on the T3/E3 interfaces:

T3 Mode

The following features are offered on T3 interfaces:

- Framing - M13 and C-bit parity
- Line build out - short (0 to 250 feet) and long (250 to 450 feet)
- Line interface - 75-ohm BNC coax female connectors
- Clock - *line* (slaved to network receive clock) and *internal* (private clock source)
- Line rate - 44.736 Mbps (gross rate including overhead and payload)
- Full Rate - 44.2 Mbps (payload rate only)
- Sub-rate - approximately 3 Mbps increments up to 44.2 Mbps
- Sub-rate compatible DSUs supported:
  - Quick Eagle (formerly Digital Link) DL3100 T3 or Cisco-300-44210 Kbps
  - Larscom Access T45-3100-44210 Kbps
  - ADC Kentrox T3/E3 IDSU-1500-35000, 44210 Kbps
  - Adtran T3SU 300-75-44210Kbps
  - Verilink HDM 2182-1500-44210 Kbps
- Scrambling - same as for sub-rates, DSU vendor dependant
- Diagnostics - ANSI T1.107 compatible loop backs (initialized from the network)
- Performance monitoring local network port statistics - Current 15 -minute, 24-hour (96 *15-minute intervals) and total for 24 hours

E3 Mode

The following features are offered on E3 interfaces:

- Framing - G751 or bypass
- Line interface - 75-ohm BNC coax female connectors
- Clock - line (slaved to network receive clock) and internal (private clock source)

- Line rate - 34.368 Mbps
- Full rate - 34.0995 Mbps (G751)
- Sub-rate - approximately 3 Mbps increments up to 33 Mbps
- Compatible DSUs supported
  - Cisco or Quick Eagle (formerly Digital Link) DL3100 E3 -300-33.920 Kbps
  - ADC Kentrox T3/E3 IDSU
- Scrambling - Cisco mode only
- Performance Monitoring Local Network Port Statistics - Per RFC-2496- Current 15-minute, 24-hour (96 *15-minute intervals) and total for 24 hours

T1/E1 Subsystem Configuration

Each T1/E1 physical port is represented as a T1 or E1 controller. This is valid for both full rate T1/E1 mode and fractional/channelized modes. Each T1/E1 physical port (line) can be configured to run in one of the following modes:

- Full rate T1/E1 mode - full T1/E1 line bandwidth is used by one user
- Fractional T1/E1 mode - only one Channel Group is assigned to one T1/E1 physical line
- Channelized T1/E1 mode - more than one Channel Group is assigned to one T1/E1 physical line

For both fractional and channelized configurations, each configured Channel Group, which might contain individual timeslots or ranges of timeslots, uses only one of the available logical channels. All configured T1/E1 lines are recognized by the system software as serial interfaces. That implies that all of the available configuration procedures for interfaces are applicable. Each of the serial interfaces can be configured to carry data traffic with PPP encoding.

T3/E3 Subsystem Configuration

Each T3/E3 physical port is represented as a T3 or E3 controller. This is valid for both full and sub-rate T3/E3 modes. Un-channelized or “unformatted” service creates a point-to-point connection between your network equipment and that of the service provider. The T3/E3 WAN transmission line can be provisioned as follows:

- *Full rate service* is covered by national and international standards. Only one data stream at full data rate is sent over the T3/E3 line.
  - T3 - 44.2Mbps payload, Framing DS3 ANSI T1.107
  - E3 - 33.920 Mbps payload, Framing G.751.

    The entire bandwidth of the line is used to pass Frame Relay or PPP data. Frame Relay service can be provisioned in a number of ways, e.g., measured T3 service provides an unlimited (burstable) T3 with charges based on bandwidth used.
- *Sub-rate service* includes no standards. It is provisioned by T3 or E3 DSUs which transmit only one data stream at a reduced rate. Supported rates are DSU-specific. Data rates are:
  - T3 - 1 to 35 MHz in 0.5MHz steps
  - E3 - 1 to 24.5 MHz in 0.5MHz steps

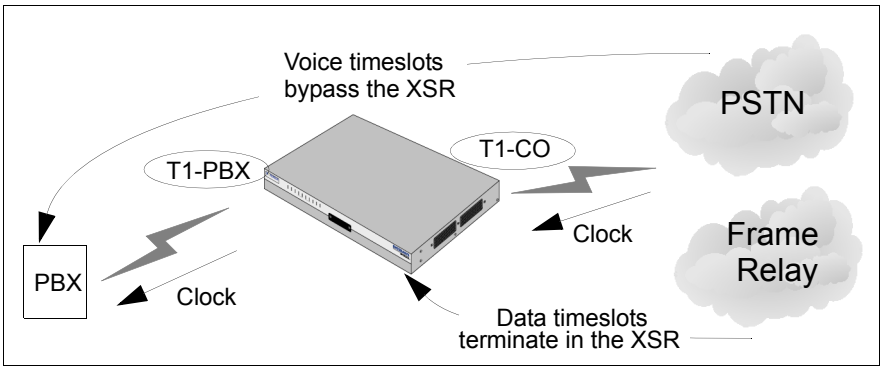
    Sub-rate T3/E3 DSUs include: Digital Link, Kentrox, Adtran, Verilink and Larscom.

- *Clear Channel service* is similar to the full rate service except that the data stream rate is slightly higher because the framing overhead bits are also used to deliver data.
  - T3 - Not Available
  - E3 - 34.368Mbps payload

T1 Drop & Insert One-to-One DS0 Bypassing

The XSR's 2-port D&I NIM is designed to cross-connect unused timeslots between the two ports and provide one T1/E1 line for both data and voice traffic, as shown in Figure 4-1. The timeslots carrying data are terminated in the on-board HDLC controller, while voice timeslots bypass the D&I NIM and are terminated in the downstream PBX. This NIM is configured with **`drop-and-insert-group`** and runs identically to the XSR's 2-port fractional T1/E1 NIM. **`Show controller t1 s/c/x`** is useful for debugging the line. Refer to the *XSR CLI Reference Guide* for associated commands.

Figure 4-1 Drop and Insert NIM Topology



The D&I NIM does not support channelized mode nor PRI.

Note: If the XSR loses power, the two T1 lines will be cross-connected by the relays. Consequently, the Central Office will not report the lines down.

Drop and Insert Features

The following features are supported by the D&I NIM:

- The D&I feature allows Channel Associated Signaling (CAS) voice DS0 timeslots to be taken off the Central Office (CO) T1 or E1 interface and inserted into timeslots of the PBX T1 or E1 interface, as long as both interfaces are on the *same* NIM card.
- You *must* configure the timeslots belonging to the data channel group. All timeslots not within the data channel group are considered idle and bypassed between the T1 or E1 ports.
- D&I timeslots need not be contiguous - all idle timeslots on both the T1 or E1 interface will be automatically connected and transparently pass voice channels. Idle timeslots are not configured to take part in *channel groups*.
- The CO T1/E1 and PBX T1/E1 ports are bypassed by relays to maintain a CO-PBX link in case of a power outage or watchdog timeout. So, when the XSR with the D&I NIM is inserted between the PBX and the T1 line of the CO, there is no need to reconfigure the PBX.

- The D&I NIM supports different framing and line coding on the CO T1 and PBX T1 ports (ESF versus D4, B8ZS versus AMI), but if the ports are not identically configured, the bypass relays will not restore the voice link in the case of an XSR failure or power outage.
- The CO T1/E1 port supports one PPP or Frame Relay channel.
- The T1E1 Drop & Insert NIM includes the same data functionality as the standard two-port Fractional T1E1 NIM.
- The PBX T1 port need not support a data channel.

Note: All of the above features are supported for the E1 interface, as well. The E1's timeslot 16 is reserved for CAS signaling and can not be configured for data.

Refer to "Configuring the D&I NIM" on page 4-13 for a configuration example.

Configuring Channelized T1/E1 Interfaces

Perform the following steps to set up a channelized T1/E1 port. This T1 example is similar to that for an E1 controller and associated port.

1. Specify the **slot/card/port** address of the controller to be configured:
   ```
   XSR(config)#controller t1 0/1/0
   ```
   This command automatically adds a full-rate channel group on port 0 and acquires Controller mode. Alternatively, you can add a different port and manually add a channel group using any of 24 timeslots.
2. Specify the **clock source** for the controller.
   ```
   XSR(config-controller<T1-1/0>)#clock source line
   ```
   The clock source command determines which one of the circuits provides the clocking signal.
3. Specify the controller's **framing** type:
   ```
   XSR(config-controller<T1-1/0>)#framing esf
   ```
4. Specify the controller's **line encoding** type:
   ```
   XSR(config-controller<T1-1/0>)#linecode b8zs
   ```
5. Specify a **channel group** and map **timeslots** to the group. Enter the **channel-group** command.
   ```
   XSR(config-controller<T1-1/0>)#channel-group 0 timeslots 1,3-5,8
   ```
   The example specifies channel group 0 and maps timeslots 1, 3 through 5, and 8 to channel group 0.

   Note: Each channel group is represented as a serial interface and is set individually. Channel groups are created as shown above but to configure them you must acquire Interface Serial mode as shown below.
6. Enter the no shutdown command to enable the line.
   ```
   XSR(config-controller<T1-1/0>)#no shutdown
   ```
7. If IP routing is enabled, assign an **IP address** and **subnet mask** to the channel group with the **interface** and **ip address** commands:
   ```
   XSR(config)#interface serial 1/0:0
   ```
   That is, NIM 1, port 0, and Channel group 0.
   ```
   XSR(config-if<S1/0:0>)#ip address 10.1.16.2 255.255.255.0
   ```
8. Specify the **encapsulation protocol** to be used over this interface.
   ```
   XSR(config-if<S1/0:0>)#encapsulation ppp
   ```
   In this example PPP is used.

9. Add any additional configuration commands required to enable IP- or PPP-related protocols.
10. Use the **no shutdown** and **exit** commands to enable the interface and return to configuration mode. Repeat the previous steps to configure more channel groups.

```
XSR(config-if<S1/0:0>)#no shutdown
```

Configuring Un-channelized T3/E3 Interfaces

Perform the following steps to set up an un-channelized T3 or E3 port. If you wish to use *defaults*, enter only the first two commands. The remaining commands set up IP routing, WAN/LAN ports and optional T3 values.

1. Specify the **slot/card/port** address of the controller to be configured.

```
XSR(config)#controller t3 0/1/0
```

   This command adds the serial pipe, a single channel, and acquires Controller mode.

2. Enable the Controller line.

```
XSR(config-controller<T3-0/1>)#no shutdown
```

3. *Optionally*, if you prefer to configure *internal* clocking.

```
XSR(config-controller<T3-0/1>)#clock source internal
```

4. *Optionally*, if you wish to configure sub-rate mode, enter the following commands to set the proprietary DSU mode and bandwidth. For example:

```
XSR(config-controller<T3-0/1>)#dsu mode adtran
XSR(config-controller<T3-0/1>)#dsu bandwidth 30074
```

5. If IP routing is enabled, assign an ***IP address*** and ***subnet mask*** to the channel group.

```
XSR(config)#interface serial 1/0:0
```

   That is, NIM 1, port 0, and Channel group 0.

```
XSR(config-if<S1/0:0>)#ip address 10.1.16.2 255.255.255.0
```

6. Specify the ***encapsulation*** **protocol** to be used over this interface.

```
XSR(config-if<S1/0:0>)#encapsulation ppp
```

   In this example PPP is used.

7. Enable the *Serial* line.

```
XSR(config-if<S1/0:0>)#no shutdown
```

8. *Optionally*, enter a *static route* to connect to a remote site.

```
XSR(config-if<S1/0:0>)#ip route 5.5.5.0 255.255.255.0 10.1.16.3
```

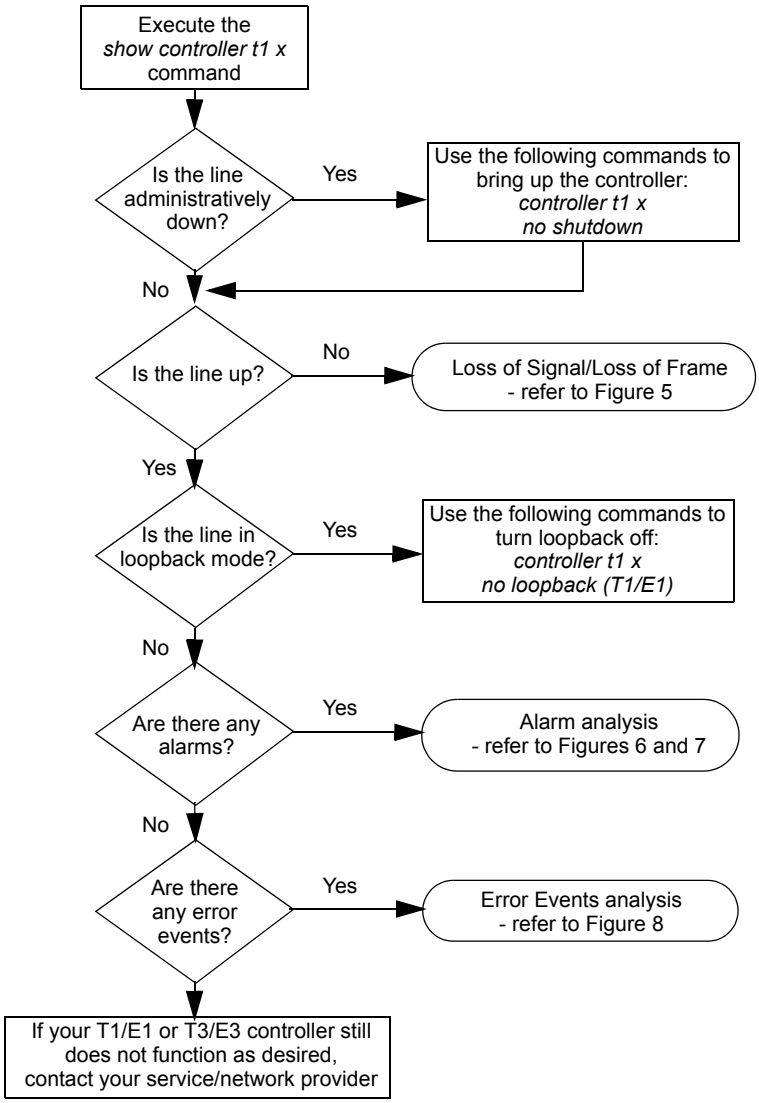
9. Set LAN interfaces. GigabitEthernet interface 2 is configured with *speed* and *duplex* values.

```
XSR(config)#interface GigabitEthernet 1
XSR(config-<G1>)#ip address 192.168.72.135 255.255.255.0
XSR(config-<G1>)#no shutdown
XSR(config)#interface GigabitEthernet 2
XSR(config-<G2>)#speed 100
XSR(config-<G2>)#duplex full
XSR(config-<G2>)#ip address 6.6.6.1 255.255.255.0
XSR(config-<G2>)#no shutdown
```

Troubleshooting T1/E1 & T3/E3 Links

This section describes general procedures for troubleshooting T1/E1 lines on the XSR. The following flow diagram shows basic steps to perform.

Figure 4-2 General T1/E1 & T3/E3 Troubleshooting Flowchart



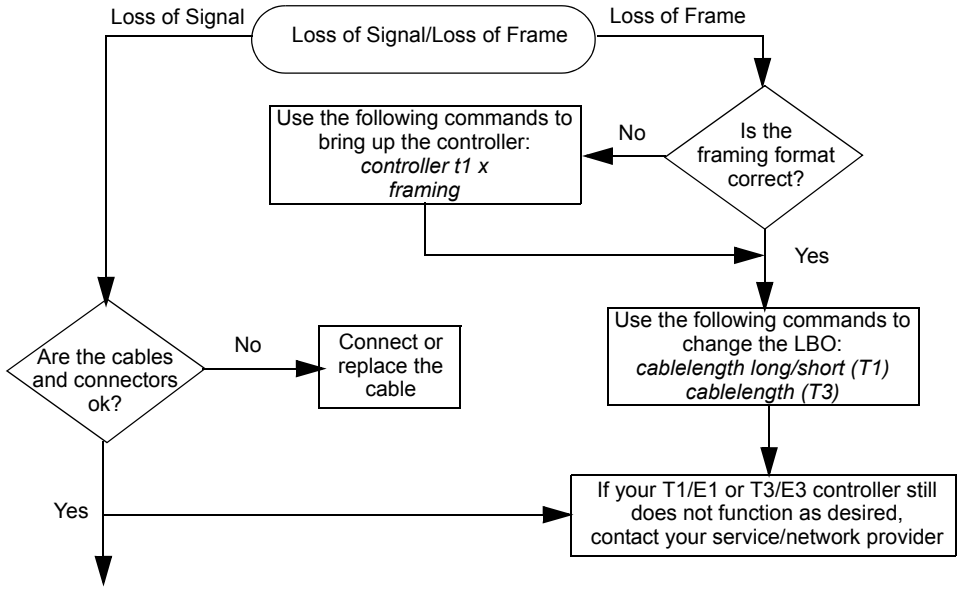
As shown in Figure 4-2, three troubleshooting actions are defined:

- T1/E1 & T3/E3 Physical Layer (Layer 1) troubleshooting (loss of signal/frame)
- T1/E1 & T3/E3 Alarm Analysis
- T1/E1 & T3/E3 Error Events Analysis

T1/E1 & T3/E3 Physical Layer Troubleshooting

This section describes the techniques and procedures to troubleshoot T1/E1 or T3/E3 physical layer problems. The troubleshooting flowchart below displays the procedures described in the following section.

Figure 4-3 T1/E1 & T3/E3 Physical Layer (Layer 1) Troubleshooting Flowchart



The **`show controller`** command displays current controller parameters, status and statistics data. Most controller errors are caused by incorrectly configured lines including line coding, framing, and clock source parameters.

When a T1/E1 or T3/E3 controller (port) is created with an associated channel or channel group, it can exist in three states:

- *Administratively down*:

  If you do not enter the **`no shutdown`** *command when you create the controller (port) or enter the* **`shutdown`** *command for an already created controller (port), you create all associated channel-groups on that controller (port) but they are disabled.*

- *Down*:

  If you enter the **`no shutdown`** *command for the controller in Controller mode, all associated channel groups are enabled on the physical level but the controller senses an alarm on the line and will not pass user data.*

- *Up*:

  Only when the associated interface is enabled using the **`no shutdown`** *command in Interface mode does the channel-group become operational. This is because there is one-to-one mapping between channel groups and interfaces; if an interface is administratively down so is its channel group - even if the controller port is up!*

Follow these steps to restart the controller to correct this type of error:

1. Enter Controller mode. For example:

```
XSR(config)#controller t1 1/0
XSR(config-controller<T1-1/0>)#
```

2. Restart the controller:

```
XSR(config-controller<T1/0>)#no shutdown
```

If the T1/E1or T3/E3 controller and line are *not up*, check that either the T3/E3 NIM LOS or LOF LEDs are shining or one of the following messages displays in the **`show controller`** output:

- Receiver has loss of frame (LOF), or
- Receiver has loss of signal (LOS)

Complete the following steps if the receiver has *loss of frame*:

1. Ensure the framing format set on the port matches the framing format of the line. If needed, change the framing format configuration.
2. Change the Line Build-Out (LBO) using **cablelength long/short** (T1) or **cablelength** (T3) commands. If needed, contact your service provider for more details on LBO configuration.

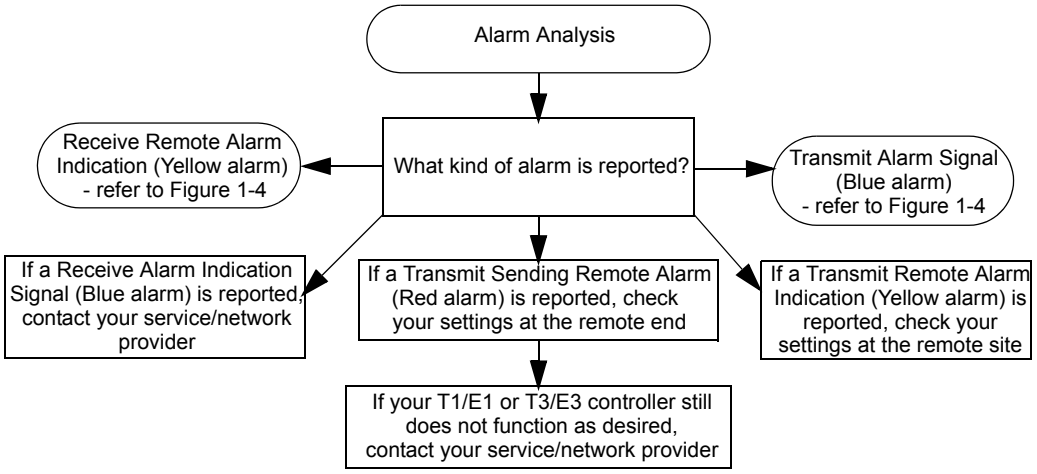
Complete the following steps if the receiver has a *loss of signal*:

1. Ensure the cable between the interface port and the T1/E1 or T3/E3 service provider equipment is connected correctly.
2. Check the cable integrity by looking for breaks or other physical abnormalities in the cable.
3. Check the cable connectors.

T1/E1 & T3/E3 Alarm Analysis

Perform the following steps to troubleshoot for various alarms that can occur within the T1/E1 or T3/E3 subsystem. The following troubleshooting flowchart displays the procedures.

Figure 4-4 T1/E1 & T3/E3 Alarm Analysis Troubleshooting Flowchart (Part 1)



Receive Alarm Indication Signal (AIS - Blue Alarm)

1. Check that the framing format of the controller port matches the framing format of the line provided by your service provider.

Receive Remote Alarm Indication (RAI - Yellow Alarm)

1. Insert an external loopback cable into the T1/E1 or T3/E3 port.
2. Use the **`show controller`** command to check for alarms. To identify the type of the alarm, analyze the log report of the XSR. If alarms are reported, contact your service provider.
3. Remove the external loopback cable and the reconnect line.
4. Check the cabling.
5. Power cycle the XSR.
6. Connect the T1/E1 or T3/E3 line to a different port and configure the port with the same settings as the line. If the problem does not persist, then the fault lies with the port. In this case, contact Technical Support for assistance.

Transmit Remote Alarm Indication (RAI - Yellow Alarm)

1. Check the settings at the remote end to ensure that they match your port settings.
2. Contact your service provider if the problem persists.

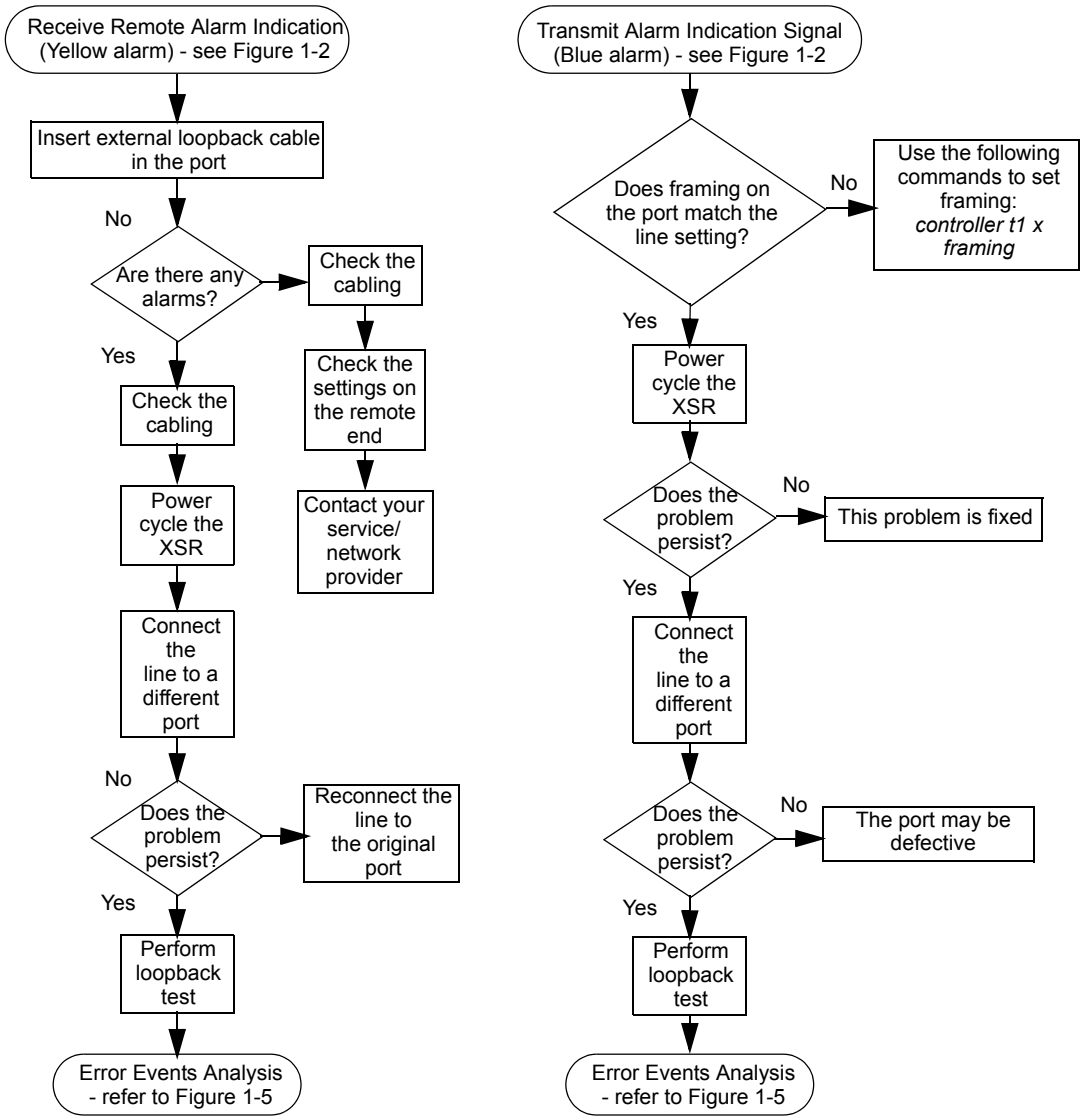
Transmit Sending Remote Alarm (Red Alarm)

1. Ensure the framing format configured on the port matches the framing format of the line. If not, change the framing format on the controller to match the format of the line.
2. Check the settings at the remote end and ensure that they match your port settings.
3. Contact your service/network provider if the problem persists.

Transmit Alarm Indication Signal (AIS - Blue Alarm)

1. Ensure that the framing format configured on the port matches the framing format of the line. If not, change the framing format on the controller to match the format of the line.
2. Power cycle the XSR.
3. Connect the T1/E1or T3/E3 line to a different port. Configure the port with the same settings as the line. If the problem persists, perform an external loopback test on that port. If the problem persists, contact Technical Support for assistance.

Figure 4-5 T1/E1 & T3/E3 Alarm Analysis Troubleshooting Actions Flow (Part 2)

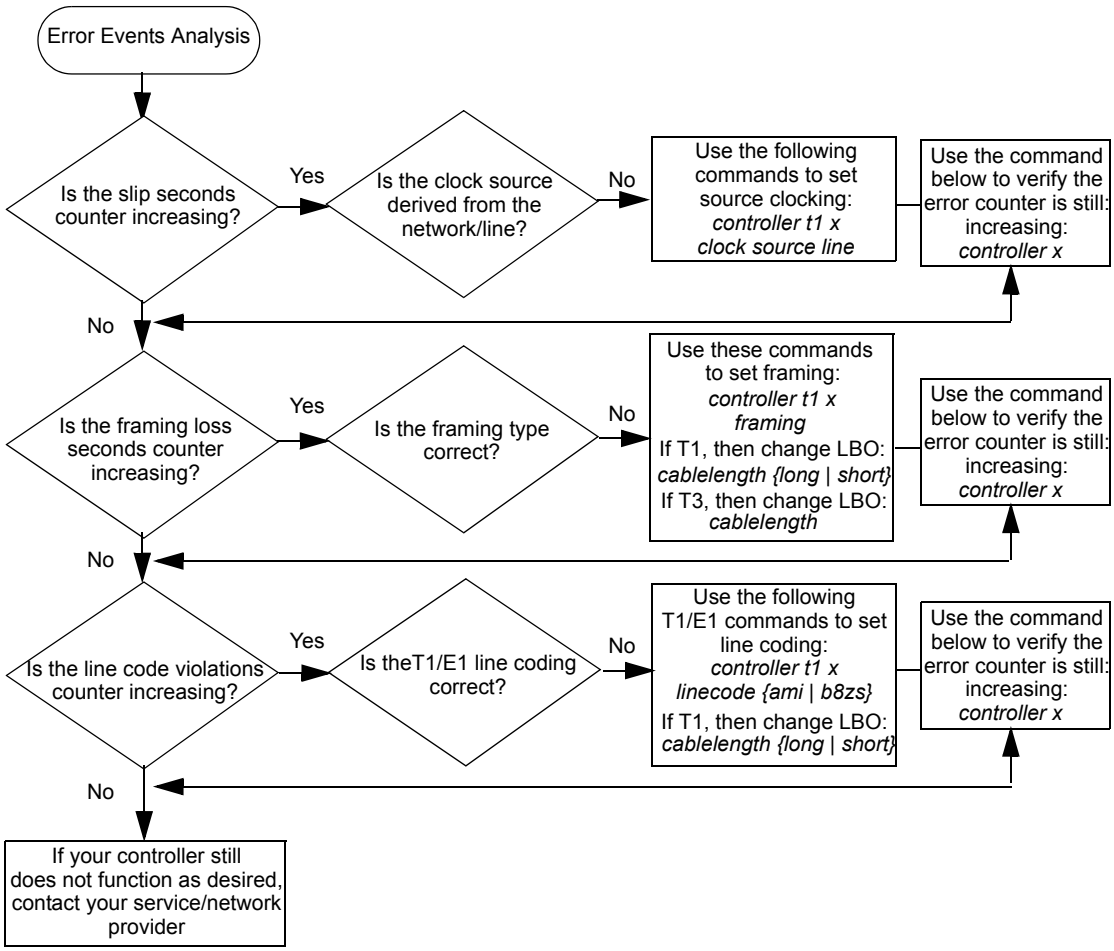


T1/E1 & T3/E3 Error Events Analysis

This section describes various error events that can occur on controller lines and provides troubleshooting information to fix some of these errors. The **`show controller`** command displays the status and statistics specific to the hardware. This information is useful for diagnostic tasks.

All problems that can occur are captured by the underlying hardware and reported by the **`show controller`** output. Here are some troubleshooting steps you can perform with a flowchart displaying troubleshooting actions.

Figure 4-6 T1/E1 & T3/E3 Error Events Analysis Troubleshooting Flowchart



Note: Statistics displayed with the **`show controllers`** command are reset every 24 hours. That is, once the port or line is created with the **`controller`** command, the 24-hour timer starts.

Slip Seconds Counter Increasing

If slip seconds are present on the T1/E1 or T3/E3 line, usually there is a clocking problem. Complete the following steps to correct this problem:

1. Ensure the clock source is derived from the network (source clocking extracted from the line).
2. Set the T1/E1 or T3/E3 clock source from Controller mode if needed.

Framing Loss Seconds Increasing

If framing loss seconds are present on the T1/E1 line, usually there is a framing problem. Perform the following steps to correct this problem:

1. Ensure the framing format configured on the controller port matches the framing format of the line.
2. Set the T1/E1 framing mode from Controller mode if needed.
3. *(T1 Only)* Change the line build out (LBO) using the **cablelength long** or **cablelength short** command if needed.

Line Code Violations Increasing

If line code violations are present on the T1/E1 line, usually there is a line encoding problem. Perform the following steps to correct this problem:

1. Ensure the line coding format configured on the controller port matches the framing format of the line.
2. Set the T1/E1 linecode mode from Controller mode if needed.
3. *(T1 Only)* Change the line build out (LBO) using the **cablelength long** and **cablelength short** command if needed.

Configuring the D&I NIM

The following D&I configuration instructs the XSR to terminate timeslots 1 through 7 of controller T1-0/1/0 into a PPP channel and bypass the rest of the timeslots from T1 controller 0/1/0 to controller T1 0/1/1. Controller port *T0/1/0* is connected to the Central Office and controller port *T0/1/1* is connected to the PBX down stream. *Serial 0/1/0:0* is the data channel on the Telco side of the NIM. Note that the clock source is set to *line* at the CO and *internal* locally. Alternately, if you require a line speed of 64 Kbps, you can use the default line coding B8ZS.

```
XSR(config)#controller t1 0/1/0
XSR(config-controller<T1-0/1/0>)#drop-and-insert-group
XSR(config-controller<T1-0/1/0>)#channel 0 timeslots 1-7 speed 56
XSR(config-controller<T1-0/1/0>)#clock source line
XSR(config-controller<T1-0/1/0>)#line ami
XSR(config-controller<T1-0/1/0>)#no shutdown
XSR(config-controller<T1-0/1/0>)#exit

XSR(config)#interface s1/0:0
XSR(config-if<S0/1/0:0>)#encapsulation ppp
XSR(config-if<S0/1/0:0>)#no shutdown
XSR(config-if<S0/1/0:0>)#exit

XSR(config)#controller t1 0/1/1
XSR(config-controller<T1-0/1/1>)#drop-and-insert-group
XSR(config-controller<T1-0/1/1>)#no channel 0
XSR(config-controller<T1-0/1/1>)#line ami
XSR(config-controller<T1-0/1/1>)#clock source internal
XSR(config-controller<T1-0/1/1>)#no shutdown
```

5

Configuring IP

Overview

This document describes the XSR's IP protocol suite functionality including:

- General IP features (ARP, ICMP, TCP, UDP, TFTP, Telnet, SSH, NAT, VRRP, Proxy DNS, et al.)
- IP routing (RIP, OSPF, static routing, triggered-on-demand RIP updates)
- VLAN routing
- Applicable MIBs
- Configuration examples

IP protocol, the main protocol of the TCP/IP suite, interconnects systems of packet-switched computer communication networks. It transmits TCP, UDP, and ICMP information as IP datagrams in a 32-bit addressing scheme where an IP address is represented by four fields, each containing 8-bit numbers. IP uses three types and five classes of addresses:

- Unicast - destined for a single host
- Broadcast - destined for all hosts on a given network
- Multicast - destined for a set of hosts belonging to a multicast group
- Class A, B, and C - used as a pool for unicast addresses
- Class D - used for multicast addresses
- Class E - reserved for future use

General IP Features

The following features are supported on the XSR:

- Meets requirements for IPv4 routers - RFC-1812
- Ethernet 802.3 support of SNAP and DIX frame format
- Internet Standard Subnetting Procedure (ISSP) - RFC-950
- ARP - dynamic, static, and proxy ARP
- Proxy DNS
- IP subnet zero (always enabled)

- The Router ID can be configured with the **`ip router-id`** command or, if not configured, automatically generated from the existing configuration. Alternately, the Router ID is automatically generated as the highest non-zero IP address among all loopback interfaces or, if no loopback interface is configured, the highest non-zero IP address among standard configured interfaces. A loopback interface can be configured with the **`interface loopback`** command.
- BOOTP/DHCP relay
- Broadcasting: Directed and UDP broadcast forwarding
- ICMP
  - ICMP Router Discovery Protocol
  - Destination unreachable message
  - Time exceeded message
  - Parameter problem message
  - Redirect message
  - Echo or echo reply message
- TCP
  - Window and acknowledgement
  - TCP maximum segment size
  - Congestion control in TCP/IP
  - TCP extensions for high performance
  - TCP selective acknowledgement option
- UDP
- Telnet
- SSH
- TFTP
- MTU
  - Path MTU discovery protocol: Support for external MTU discovery (data passing through the XSR). An ICMP MTU size exceeded message is issued if large packets transit the XSR with the “don't fragment” bit set. These packets are dropped per RFC-1191. Also, the XSR does not originate MTU discovery, that is, application data originating in the XSR.
  - Set MTU size per interface
- IP Interface
  - Numbered interfaces
  - Un-numbered interfaces on point to point links
  - NBMA support
    - Point to multipoint networks
    - Fully meshed networks
  - Secondary IP

- Troubleshooting Tools
  - Ping
  - Traceroute
- IP Routing
  - RIP
  - Triggered-on-Demand RIP updates
  - OSPF including Database Overflow (RFC-1765) and Passive Interfaces
  - OSPF debugging
  - Static routes
  - Default network
  - CIDR (IP classless)
  - Router ID configuration RFC-1850
  - Configurable RIP and OSPF timers
  - Per interface OSPF poll timer
- VLAN Routing
  - Layer 3 (IPv4) forwarding of Ethernet frames with 802.1Q VLAN over FastEthernet/ GigabitEthernet interfaces
  - VLAN IDs - up to 64 unique VLAN IDs per physical interface in a range from 0 to 4094
  - User priority (priority bits) in a VLAN- tagged frame:
  - - XSR does *not* prioritize traffic when forwarded
  - - But priority preserved when forwarded to another VLAN port
  - - Locally sourced VLAN frames and frames not accessing a VLAN interface will have their priority bits set to 0
  - Encapsulation supported over VLAN for PPPoE
  - VLAN Routing supported for: OSPF, RIP, Static routes
  - IP support over VLAN includes: Secondary IP addresses, NAT, Policy Based Routing (PBR), ACLs, standard IP applications including Ping, Traceroute, Telnet, Helper Addresses, Directed Broadcast, VPN, Firewall, DHCP Server, et al.
  - VRRP and QoS supported over VLAN physical interfaces only
  - QoS with VLAN supporting up to four priority queues per interface, input traffic classification based on user priority bits in the VLAN header, and output traffic marking by priority
  - One global ARP table maintained and is shared across VLANs
  - Duplicate MAC addresses not allowed across VLANs
- Policy Based Routing (PBR)
- Real Time Protocol (RTP) Header Compression
- Network Address Translation - static (NAT), Network Address Port Translation (NAPT), dynamic NAT pool mapping with overload, PPTP/GRE ALG and arbitrary IP address for NAPT, on the interface and port-forwarded static NAT, multiple NATs on an interface.

- Virtual Router Redundancy Protocol (VRRP): RFC-2338 and Definitions of Managed Objects for the Virtual Router Redundancy Protocol: RFC-2787
- Equal-Cost Multi-Path (ECMP) per packet and per flow (round robin) for OSPF, BGP and static routes (RIP excluded)
  - Unequal cost multi-path, redistribution of equal-cost paths, and multiple default routes based on default networks with multiple equal-cost next hops are not supported

ARP and Proxy ARP

ARP (Address Resolution Protocol) is a link-level protocol which provides a mapping between the two different forms of addresses: 32-bit IP addresses and hardware addresses used by the data link. The protocol dynamically keeps entries in the ARP Table and can accept statically configured entries according to RFC-826.

The **`arp`** command adds or deletes permanent entries to the ARP Table while the **`arp-timeout`** command sets the duration for an ARP entry to stay in the ARP table before expiring. The **`show ip arp`** command displays real-time entries in the ARP table.

Proxy ARP lets the XSR answer ARP requests on one network for a host on another network. The router acts as a proxy agent for the destination host, relaying packets to it from other hosts, as defined by RFC-1027. It is configured with the **`ip proxy-arp`** command.

Proxy DNS

Proxy servers act as intermediaries between DNS clients and servers. They handle outgoing queries and answer them from data obtained by sending one or more queries to other DNS servers. Typically, they cache data received, reducing traffic and latency if the data are frequently requested.

XSR's *forwarding* proxy server talks to other proxy or DNS servers without performing DNS resolution. They simply forward request and replies, relying on real DNS servers for name resolution, and cache the replies to avoid having to request resolution again with these benefits::

- A proxy DNS server releases the function of the resolver on the client side, and by doing so simplifies client implementation.
- Since the proxy acts as an intermediary between DNS clients and servers, no direct connection between clients and servers is needed.
- Instead of caching the DNS database in each client, proxy DNS maintains a centralized cache for DNS resolution.

You can enable DNS proxy with **`ip proxy-dns enable`**, specify a proxy server with **`ip proxy-dns name-server`**, clear the DNS cache table with **`clear ip proxy-dns cache`**, verify DNS settings with **`show running-config`**, and display DNS cache settings with **`show ip proxy-dns cache`**.

BOOTP/DHCP Relay

The Bootstrap Protocol (BOOTP) is used by systems with no capability of learning their IP addresses. BOOTP requests can be forwarded by routers, not necessitating one server on each physical network. Normally, BOOTP/DHCP requests are not forwarded, since they are local broadcasts which are not designed to be forwarded, and they have an invalid nonroutable IP source address, such as 0.0.0.*x*. But the agent replaces the destination address with a helper address, and the source address with its own address, then forwards it. You can set the helper address with the **`ip helper-address`** command.

When a BOOTP/DHCP response is received, the packet is sent to the requester as a unicast IP packet, according to RFC-951, with clarifications in RFC-1532.

The source addresses of the relayed BOOTP/DHCP packets can be selected using **ip dhcp relay-source gateway** command. By default, IP stack selects the outgoing interface address as the source address.

Broadcast

A broadcast is a packet destined for all hosts on a given network as defined by RFC-919 and RFC-922.

Directed Broadcast

An IP directed broadcast is a datagram sent to the broadcast address of a subnet to which the sending device is not directly attached. The directed broadcast is routed through the network as a unicast packet until it arrives at the target subnet, where it is converted into a link-layer broadcast.

The XSR supports directed broadcast using the **`ip directed-broadcast`** command. For security purposes, restrictions can be set by defining and applying an ACL and by restricting the protocols. There are two types of directed broadcasts, described as follows:

- A *net-directed broadcast* specifies a destination address with a host ID of all 1s. For example, a Class A net-directed broadcast destination address is **`netid.255.255.255`** where the *netid* is the Class A network ID. The XSR forwards it by default.
- A *subnet-directed broadcast* also specifies a destination address with a host ID of all 1s, but with a *specific* subnet ID. For example, a Class A subnet-directed broadcast destination address is **`netid.subnetid.255.255`** where netid is the Class A network ID and *subnetid* is the subnet. The XSR forwards it by default.

Local Broadcast

A local broadcast is a broadcast to a destination address of all ones -255.255.255.255. This broadcast should not be forwarded. It may be:

- Consumed by the router, or,
- Forwarded using UDP broadcast forwarding, a feature which allows XSR to forward a UDP local broadcast to one or more new destinations if the UDP port of the datagram matches the configured one. The destination address is replaced by a configured unicast address with no change in the source address (except BOOTP/DHCP relay).

ICMP

The Internet Control Message Protocol (ICMP) communicates error messages and other conditions that require attention as defined by RFC-792.

ICMP messages are transmitted in IP datagrams and are usually acted on by the IP layer or higher layer protocols (TCP/UDP). The XSR supports these message types: *ICMP router discovery, destination unreachable, time exceeded, parameter problem, redirect, echo* or *echo reply.* The XSR also supports the ICMP Router Discovery Protocol (IRDP) which dynamically discovers routes to other networks, as defined by RFC-1256.

IRDP allows hosts to locate routers and can also infer router locations by checking RIP updates. When the XSR operates as a client, router discovery packets are generated. When the device operates as a host, router discovery packets are received. The IRDP client/server implementation

does not actually examine or store full routing tables sent by routing devices, it merely keeps track of which systems are sending such data. Using IRDP, the XSR can specify both a priority and the time after which a device should be assumed down if no further packets are received.

The XSR enables router discovery and associated values with the **ip irdp** command. The router also supports the redirection of packets routed through the same port they were received on with the **ip redirect** command.

TCP

The Transmission Control Protocol (TCP) is a transport layer language providing a connection-oriented, reliable, byte-stream service described by RFC-793.

UDP

The User Datagram Protocol (UDP) is a simple, datagram-oriented, transport layer protocol where each operation by a process produces exactly one UDP datagram, which causes one IP datagram to be sent. RFC-768 describes UDP.

Telnet

Telnet provides a general, bi-directional, 8-bit byte-oriented communications facility that is always enabled on the XSR. It is a standard method by which terminal devices and terminal-oriented processes interface, as described by RFC-854. A Telnet connection is a TCP connection used to transmit data with interspersed Telnet control data. Two entities compose a Telnet link:

- A Telnet *server* is the host which provides some service
- A Telnet *user* is the host which initiates communications

Telnet port (23) and server settings can be configured on the XSR with the **ip telnet port** and **ip telnet server** commands. You can also configure Telnet client service to other servers with the **telnet ip_address** command. Refer to the *XSR CLI Reference Guide* for more information.

SSH

The Secure Shell (SSH) protocol provides for safe remote login and other network services on the XSR. Along with a user-supplied client, the SSHv2 server allows you to establish a secure connection, similar to that provided by an inbound Telnet connection with an important exception.

Unlike Telnet, SSH encrypts the entire connection with the XSR to hide your identity, provides data confidentiality via the negotiated choice of encryption types such as 3DES, and offers message integrity through hashing using SHA-1 or other algorithms such as MD5 or crypto library support for third-party encryption ciphers such as Blowfish, Twofish, AES, CAST and ARCfour. Enabled (by default) on the CLI with the **ip ssh server** command, SSH is further configured by specifying users, passwords, privilege level and policy with the **aaa user**, **password**, **privilege 15** and **policy** commands, the idle *timeout* interval for your SSH session with the **session-timeout ssh** command, and user authentication with the **aaa** SSH command.

Upon configuring the XSR for the first time, you should generate a *host key pair* with the **crypto key dsa** command, otherwise, if no key is generated, the default key is used for any connection request. Generated host keys are encrypted and stored in the *hostkey.dat* file within Flash where the file cannot be read or copied. All SSH connection requests use the host keys stored in the

hostkey.dat file unless none have been generated or the content of the file is corrupted in which case default keys are used to secure the connection.

Note: SSH is *enabled* by default on port 22. Be aware that with SSH enabled, traditional facilities such as FTP, TFTP, and Telnet are *not* disabled so to ensure system security, you must disable other communication services.

A number of SSH clients are commercially available. Enterasys recommends the PuTTY client freeware as compatible and easy to configure. For step-by-step instructions on installing PuTTY and configuring SSH, refer to "Configuring Security" in the *XSR User's Guide*.

Trivial File Transfer Protocol (TFTP)

TFTP is a bare bones file transfer protocol, as defined by RFC-1350, using UDP to simplify transport with less overhead. The XSR provides TFTP client functionality using the **`snmp-server tftp-server-list`** and **`copy <file>`** commands. Always enabled on the router, it is useful to save and restore configuration files and images.

Refer to the *XSR CLI Reference Guide* and "Managing the XSR" on page 2-1 for more information.

IP Interface

IP interfaces are virtual circuits used to pass traffic between a physical port and the XSR forwarder. IP interfaces have the following characteristics:

- *Numbered* interfaces have IP addresses assigned to them.
- The port can be pinged to monitor its status with the **`ping`** command.
- Some routing protocols require the interface to have an IP address.
- The command **`interface`** <**`serial`** | **`fast/gigabitethernet`** | **`bri`** | **`dialer`** | **`loopback`** | **`vpn`** | **`multilink`** | **`atm`**> sets all XSR interfaces.
- *Un-numbered* interfaces are not assigned IP addresses
  - Un-numbered interfaces may be used on point-to-point networks. By default, the address used by the unnumbered interface when it generates a packet is the router ID, which is the address of the highest, non-zero configured loopback interface. An unnumbered interface address can be configured to be the address of a specified numbered interface. The **`ip unnumbered`** command sets interface parameters on the XSR.
  - An un-numbered interface cannot be pinged to monitor its status.

Secondary IP

Enabling secondary IP allows multiple IP addresses to be configured on the same physical network interface and multiple subnets to share one MAC address. Secondary addresses are treated largely like primary addresses, but not exactly the same, as explained below.

Secondary IP is useful when there are insufficient host addresses on a network segment. Configuring several subnets on the router interface which connects the network segment combines these logical subnets into one physical segment making more host addresses available.

Interface & Secondary IP

The XSR supports secondary IP on Ethernet networks only. All other ports, including loopback interfaces, support one IP address per interface only.

An XSR interface can support one primary IP address and multiple secondary IP addresses. Including all XSR interfaces, the total of supported secondary IP addresses allowed depends on the amount of the installed memory, although at present ten secondary IP addresses are supported despite the memory size. All system interfaces share the pool of secondary addresses. For example, if FastEthernet 1 uses eight secondary addresses, FastEthernet 2 is allowed no more than two secondary addresses.

Secondary IP is subject to the following rules:

- Primary and secondary IP addresses on the same interface are not allowed to exist in the same subnet, nor allowed to exist in the same subnets already occupied by other interfaces.
- Packets generated by the XSR, except the route update packet, are always sourced by the IP address of the outgoing interface which is in the same subnet as the IP address of the next-hop the packet should be forwarded to.
- All routers on the same segment should share the primary network number or some protocols, such as OSPF, may not work properly.
- If any router on a network segment uses a secondary address, all other devices on the same segment must also use a secondary address from the same network or subnet. Inconsistent use of secondary addresses on a network segment can quickly cause routing loops.
- Specify the primary IP address before any secondary IP addresses on the same interface. Conversely, before deleting a primary address, all secondary IP addresses should be removed.
- You can configure OSPF, RIP or static routes on each primary and secondary IP address.
- A secondary IP address is configured using the **`ip address secondary`** command.

ARP & Secondary IP

For each IP address configured on the interface, including primary and secondary IP addresses, the corresponding static ARP entry should be maintained in the static ARP table. Primary and secondary IP addresses on the same interface share the same MAC address of the interface.

When an ARP request is received, the destination IP address in the ARP packet will be checked against the primary IP and all secondary IP addresses. If found, an ARP reply will be sent back with the MAC address of the interface. When sending an ARP request, the source IP address used in the ARP packet should be on the same subnet as the destination IP.

ICMP & Secondary IP

When ICMP Echo packets are received by the XSR, the destination IP address is checked against all configured IP addresses including primary and secondary addresses. Any ICMP Echo packet addressed to the subnet broadcast addresses will be dropped without returning a response.

ICMP Echo Replies are generated by swapping the destination and source IP addresses in the received ICMP Echo packets.

By default, ICMP Echo packets generated by the XSR's **`ping`** command will be sourced by the IP address of the outgoing interface which is in the same subnet as the IP address of the next-hop the ICMP packet should be forwarded to.

When ICMP Mask request packets are received, the destination IP address will be matched against the entire subnet network associated with the primary and secondary IP addresses. The matched IP address will then be used as the source IP address of the reply packet.

Routing Table Manager & Secondary IP

If the interface is up, each primary and secondary IP address will have an entry in the routing table as a directly connected route. If the interface is rejected or the IP addresses configured on it are removed, the Routing Table Manager (RTM) will delete corresponding table route entries.

If any IP address - primary and secondaries - is deleted or changed, any static route based on the next hop reachable through that IP address will be removed from the active routing table. And if the IP address is restored, any static route removed earlier will be restored in the active table.

OSPF & Secondary IP

In OSPF, HELLO messages use the primary IP address as the source address. Adjacencies are set up based on the primary IP address *only*. Designated routers (DR) and back-up DRs use the primary IP as their IP addresses. The virtual link uses the primary IP only, as well.

OSPF can be enabled on primary and secondary IP addresses but should be enabled on the primary *first*. Also, if OSPF is used for routing, all OSPF-enabled secondary addresses of an interface should be configured in the same OSPF area as the primary address to function properly.

OSPF can be selectively enabled on a secondary IP address as long as it is already enabled on the primary IP address.

RIP & Secondary IP

If RIP is used for routing, route updates should be multicast or broadcast to each subnet represented by both the primary and secondary IP addresses.

If an interface is configured with a secondary IP address and split horizon is enabled, route updates learned from one specific network cannot be sent back to the same physical network. Only one routing update is sourced per network number if split horizon is disabled.

RIP can be selectively enabled on primary and secondary IP addresses.

Unnumbered Interface & Secondary IP

If an unnumbered interface attempts to borrow an IP address from an Ethernet interface upon which a secondary IP address is configured, only the primary IP address can be borrowed. Also, secondary IP cannot be configured on an unnumbered interface.

NAT & Secondary IP

Only the primary IP address on the specified interface is used for NAT.

DHCP & Secondary IP

DHCP operates in the same manner regardless if secondary IP addresses are configured or not. Only one IP pool is employed even if multiple IP addresses are configured on a single interface.

VPN & Secondary IP

Secondary IP addresses are not supported on VPN virtual interfaces.

Concerning secondary IP addresses assigned to physical interfaces, if an interface constitutes the endpoint of a VPN tunnel, the *primary* IP address is always used as that tunnel endpoint. For the trusted interface upon which EZ-IPSec Network Extension Mode is running, only the SPD for the *primary* IP address assigned to the internal interface will be created.

VRRP & Secondary IP

Multiple virtual IP addresses per Virtual Router (VR) are available to support multiple logical IP subnets on a single LAN segment. Secondary IP interacts with the XSR's implementation of the Virtual Router Redundancy Protocol (VRRP) as follows:

- The primary physical IP address on an interface will be selected as a VRRP primary IP address, which is used for VRRP advertisement.
- If one of the virtual IP addresses of a VR is the real physical address of the interface, all other virtual IP addresses of that VR must also be the real physical addresses of that interface.
- Conversely, if any virtual IP address is *not* the real physical address of that interface, all virtual IP address of that VR cannot be the real physical address of that interface.
- The XSR supports 11 IP addresses per VR (1 primary + 10 secondary)
- With four VR's allowed per XSR, you can configure up to 44 virtual IP addresses per XSR.

PPPoE & Secondary IP

Secondary IP is not supported on PPPoE interfaces.

Maximum Transmission Unit (MTU)

MTU is the largest frame size allowed on an interface. It is dictated by the link level limit on a particular port. Examples of link layer types are Ethernet and 802.3 encapsulation. MTU limits the bytes of data that can be sent in an IP packet using the **`ip mtu`** command. Datagrams exceeding the link layer's MTU must be fragmented. The default MTU size is 1500 bytes.

Refer to the *XSR CLI Reference Guide* for more information.

Ping

Ping is an important debugging tool for testing network layer connectivity between a source and destination address. The source represents an IP address on the XSR where the command is executed from. The destination can be any IP address on the network, including an address on the same device where a ping occurs. **`Ping`** also allows the packet size to be set.

Refer to the *XSR CLI Reference Guide* for more information.

Traceroute

Traceroute is a vital debugging tool which reports the route IP datagrams follow to a certain destination. Its output is a complete list of routers that a specific datagram crosses to reach its destination, as well as the round time trip between the XSR where the Traceroute program runs and each of these routers. The **`traceroute`** command can be issued by the XSR.

Refer to the *XSR CLI Reference Guide* for more information.

IP Routing Protocols

Routing is one of the most important functions of IP. Routing information, which is stored in a routing table, is used by the XSR to determine the route for each of the packets that pass through it. The following routing features are supported on the XSR:

- RIP, OSPF, and BGP

- Static routes
- Route redistribution
- Default network
- CIDR (classless IP)
- Configurable Router ID
- Route Preference

When you run multiple routing protocols, the XSR assigns a weight to each of them. For more information, refer to "Route Preference" on page 5-17.

RIPv1 and v2

The Routing Information Protocol (RIP) is a distance-vector protocol based on the Bellman-Ford algorithm to learn the shortest path between two points in a network. RIP is used only on networks whose longest path is 15 hops or less and is marked by the following limits on the XSR:

- MD5 authentication is not supported
- Distribution lists require an ACL to be configured

RIP uses request and response messages. Requests ask for all or part of routing table entries and responses can be sent for one of these reasons:

- Response to a specific query
- Regular updates (unsolicited response)
- Triggered updates caused by a route change

RIP specifications are RFC-1058 for RIPv1 and RFC-2453 for RIPv2. It is supported on the XSR with the following features:

- Set globally with the **`router rip`** and per interface with the **`network`** commands: they support RIP on both LAN and WAN interfaces with these default values: Receive RIPv1 and v2, Transmit RIPv1, no redistribution, no filtering and Split Horizon with no poison.
- Redistribute static routes into RIP with the **`redistribute`** command
- Redistribute RIP into OSPF and vice versa with the **`redistribute rip`** and **`redistribute ospf`** commands
- Split horizon with poisoned reverse enabled with **`ip split-horizon`**
- Triggered updates delivered by default or disabled by **`ip rip disable-triggered-updates`**
- Clear text authentication enabled by **`ip rip authentication mode`**

Note: RIP commands configured under Interface mode are independent of enabling/disabling the RIP protocol.

- RIP is configurable for:
  - *Send only* mode set by issuing **`no received interface`** to prevent RIP from receiving update packets on a specified port
  - *Receive only* mode set by issuing **`passive interface`** to prevent RIP from sending update packets on a specified port

- *Offset metric parameters* - route metrics via RIP. Adding an offset to an interface might force a route through that interface to become a backup route
- *Route filtering*, in association with access lists, is enabled by the **`distribute-list`** command
- RIP timers can be set for *update*, *invalid* and *flush* intervals with the **`timers basic`** command
- *Statistical display* commands revealing RIP counters including **`show ip traffic, show ip route, show ip`** protocols

Triggered-on-Demand RIP

Triggered-on-demand RIP (defined in RFC-2091) is available for sending routing updates on a PPP serial (WAN) port *only*. This feature updates the XSR's RIP routing table only when the topology changes or when a next hop's reachability is detected on the WAN side of the link.

This functionality reduces the on-demand WAN circuit's routing traffic letting the link be brought down when application traffic ceases. Regular RIP updates would prevent the connection from being torn down when application use ends. The following conditions govern the feature's use:

- RIP *must* be enabled
- IP split horizon *must* be enabled (default). Whether poison is enabled or not, triggered on demand will still send its updates with poison

Triggered-on-demand RIP on the XSR is implemented by this command:

- **`ip rip triggered-on-demand`** enables the functionality on a per interface basis. Be aware that this command runs on point-to-point Serial interfaces *only*.

Note: The **ip rip disable-triggered-updates** command, with the default enforced (triggered updates enabled), invokes triggered updates in a timely fashion.

Related commands include:

- **`ip rip max-retransmissions`** sets the number of retransmissions to be sent.
- **`ip rip polling-interval`** sets the polling period for triggered RIP requests.

Refer to the *XSR CLI Reference Guide* for more information on commands.

How Triggered-on-Demand RIP Works

To better understand when to configure triggered-on-demand RIP, consider how it works. *Routing updates* are sent on the WAN in the following manner:

- The full content of the routing database is sent when:
  - An update request is received. An update is sent only to the neighbor requesting it.
  - The XSR is first powered up. An update is sent through all interfaces running triggered-on-demand RIP.
  - An interface is brought up. An update is sent only out the interface which was brought up.
- A partial update of the database is sent when:
  - An interface is brought up. The new local route is advertised to all other interfaces running triggered-on-demand RIP.
  - An interface is brought down. All routes reachable through the interface that went down are advertised as unreachable to the other interfaces running triggered-on-demand RIP.

- The latest changes are sent when:
  - The routing database is modified by new data. The latest changes are sent through all interfaces running triggered-on-demand RIP.

RFC-2091 also specifies how *packet types* are handled in the following manner:

- An *update request* is defined as a request to a peer to send its entire routing database. It is sent:
  - When the XSR is powered up;
  - When an interface is brought up.
- An *update response* is defined as a message containing zero or more routes; it is retransmitted at periodic intervals until an update acknowledge is received. It is sent:
  - In response to an update request. The first response contains no routes. Other update responses will not be sent until an update acknowledge is received. Then the routing database is sent.
  - At power up. The first update response will contain no routes.
  - When a port comes up. The first response contains no routes.
  - When a port is brought down.
  - When there is fresh routing information to be propagated.
- Each update response packet sent to a peer is given a *sequence number*, a 16-bit unsigned integer.
- Responses must be received in order. Updates received with a sequence number out of order is dropped. Packets are accepted if:
  - A sequence number is one more than the previous;
  - A sequence number is the same as the previous (occurs when the ack for the previous was sent, but not received on the other side);
  - The sequence number is 0 (could occur at startup or when it wraps around).
  - The response sequence number received will be saved and used as a starting point.
- *Resynchronization* occurs with every update response.
- Update acknowledgments answer every update response.

The RFC delineates *route persistency* in the routing database as follows. Entries learned from a triggered response on participating WAN interfaces are permanent, unless certain *events* occur, in which case entries are marked as unreachable and the hold-down timer started. These events are:

- A circuit-down event has been received; all routes learned from that next hop router are marked unreachable.
- An update packet with the flush flag set is received; all routes learned from that next hop router are marked unreachable.
- Too many retransmissions of an update go unacknowledged. All routes learned from that next hop router are marked unreachable.
- An update response for an expired route comes in. That route is marked unreachable.

The XSR does not retain *alternative routes* as they are not needed for the following scenarios:

- Dialer and dialer backup connections, which are not both up at the same time. Dialer backup occurs only when the dialer interface goes down (the best route is lost; the back up interface is brought up, then an update request and reply are issued and the new route installed).

- Dial-on-demand connections.

Retransmissions are governed by the following conditions, among others:

- The retransmission timer is a periodic timer set to 5 seconds.
- A limit in the number of retransmissions will be set, after which the routes learned through the specified circuit are marked as unreachable. The maximum number of retransmissions is configurable. The default value is 36.
- After the maximum number of retransmissions has been reached, requests will continue to be sent out with a polling interval whose default value is 30 seconds. This value is also configurable. Polling will continue until a response is received.

OSPF

The Open Shortest Path First (OSPF) routing protocol is a link-state protocol as defined by RFC-2328. It supports a replicated database approach to routing where each router has a copy of the database and contributes information to the database describing the local environment of linked routers. All routers piece together the data to obtain a current map of the network. The shortest path is calculated using an algorithm based on entries in the database.

OSPF outperforms RIP as a link-state protocol: it converges faster than RIP, a distance-vector protocol; its longest path is not limited as is RIP's (to 15); and it supports subnets - a mask is linked with each advertised route. The XSR's implementation of OSPF permits route redistribution to RIP and vice versa.

Note: OSPF does not learn neighbors over unnumbered WAN interfaces with Firewall functionality enabled.

OSPF commands are provided on the XSR with the following features:

- Set globally with the **`router ospf`** and per port with the **`network <ip address> area`**: they support OSPF on LAN and WAN interfaces with these defaults: no authentication, cost 10 (LAN) or Serial (64), dead interval of 40 seconds, hello interval of 10 seconds, priority 1, and 5-second retransmit interval.
- Intra- and inter-areas, and Type 1 and 2 external routing
- Broadcast, point-to-point and point to multi-point models
- Protocol enabled/disabled with **`router ospf`**
- Area IDs identified and defined with **`network`**
- Address ranges used by ABRs defined by **`area range`**
- OSPF priority with **`ip ospf priority`**
- Cost to send a packet over interface with **`ip ospf cost`**
- Cost for default route sent into a stub area with **`area default cost`**
- Stub and NSSA set with **`area stub`** and **`area nssa`**
- Opaque Link-state Advertisement (LSA) option
- Redistribute RIP into OSPF and vice versa with **`redistribute rip`** and **`redistribute ospf`**
- Manual and automatic virtual links enabled with **`area virtual link`**
- MD5 authentication enabled per interface with **`area authentication`** and **`ip ospf message-digest-key`**

- Incremental SPF is always enabled. SPF calculation can be changed with **`timers spf`**
- Hello wait intervals with **`ip ospf dead-interval`** and **`ip ospf hello-interval`** as well as the poll timer to set up adjacencies as quickly as possible with **`ip ospf poll-timer`**
- Retransmission and link-state update intervals with **`ip ospf retransmit-interval`** and **`ip ospf transmit-delay`**
- A host of statistical display commands including: **`show ip ospf border routers`**, **`show ip ospf database`**, **`show ip ospf interface`**, **`show ip ospf neighbor`**, **`show ip ospf virtual links`**, **`show ip protocols`**, and **`show ip route`**

LSA Type 3 and 5 Summarization

The XSR supports LSA Type 3 and 5 summarization using the **`area range advertise`** and **`summary-address`** commands, respectively. Type 3 LSAs (intra routes) are summarized by an Area Border Router then injected into other areas and furnished a unique Link-State ID (Appendix E Processing) as well as the *highest* metric of the included intra-area routes. Further, the XSR installs a *discard* route for any *active* summary range of routes, defined as including at least one intra route being leaked into the area. Conversely, specifying the **`not-advertise`** value causes undesired aggregated Type 3 LSAs to be discarded, and when a summary range becomes inactive, the discard route is dropped.

Note: Summary ranges may overlap. The most specific range activates for a locally sourced route,

Type 5 LSA summarization groups locally sourced routes which have been redistributed from other protocols. The XSR's Type 5 summarization is similar to Type 3 aggregation in terms of discard routes, Appendix E processing, overlapping, and **`not-advertise`** behavior. Additionally:

- The XSR will *not* summarize Type 7 to Type 5 translations.
- The XSR produce a Type 5 LSA for active summary ranges. If a NSSA area exists, a Type 7 LSA will be produced for each NSSA area.
- The XSR should not be subjected to needless re-origination of Type 5 LSAs. For example, importing locally sourced routes which do not alter a summary's type/cost will not re-originate the summary LSA.
- Type 5 LSAs generated by translation may supplant a Type 5 LSA originating from a local source. This will not affect what is being generated into a NSSA because translations are not advertised there.
- If for a given prefix, both a summary and a locally sourced route exist, the summary will be considered the better route even if the summary includes only that locally sourced route.

OSPF Database Overflow

A router sometimes cannot maintain the Link-State database in its entirety, typically, because the database has overflowed due to importing many external Type 5 LSA routes into OSPF. You can avert this issue by properly configuring OSPF routers into stub areas or NSSAs since AS-external LSAs are omitted from this type of Link-State database. But, with an unexpected database overflow, there is not enough time to perform this type of isolation.

The XSR's **`database-overflow`** command controls this problem by limiting the number of Type 5 LSAs it imports and others as well: Types 1 through 4, 7, and 10. The command also can set a *warning* of a pending overflow and set an interval in which to exit overflow.

Each LSA type configurable for database overflow can generate a log to reflect pending *overflow*, *overflow entered* and *exited* logs in this format:

- Date and time stamp
- Router ID (IP address)
- Module (OSPF)
- Log Description
- LSA Type
- Current LSA count

The following is a high priority Pending Overflow log report:

```
May 2 12:11:32 42.42.42.2 OSPF: Database Pending Overflow, Lsa Type: router, Count: 2
```

The following is a high priority Overflow Entered log report:

```
May 2 12:13:41 42.42.42.2 OSPF: Database Entered Overflow, Lsa Type: router, Count: 2
```

The following is a high priority Overflow Exited log report:

```
May 2 12:14:24 42.42.42.2 OSPF: Database Exited Overflow, Lsa Type: router, Count: 2
```

OSPF Passive Interfaces

In some situations it is desirable to include a subnet in the OSPF routing process (and Link-State Database), without actually running OSPF on the interface of the XSR connected to that subnet. This is particularly useful for interfaces that are used as BGP peering links or for customer connectivity.

You have two choices to incorporate this subnet into OSPF:

- Redistribute it as an *external* route into OSPF.
- Include the interface in OSPF.

Typically, the later approach is preferred because it injects the route as a *native* OSPF route, subject to address summarization at an Area Border Router, while the first approach injects it as a non-summarizable *external*. But the first approach creates a security *hole* as it opens the possibility of establishing an unintended OSPF adjacency.

Passive interfaces, entered with the **`ip ospf passive`** command, suppress OSPF packet transmissions through the specified interface so there is no chance of establishing an OSPF adjacency. Also, loopback interfaces enabled in OSPF could be considered passive interfaces and treated the same way.

The XSR's passive interface functionality performs as follows:

- *Hellos* are not sent out or received on passive OSPF interfaces.
- OSPF adjacencies are not established on passive OSPF interfaces.
- OSPF passive interfaces are advertised as stub networks in the self- originated router LSA.
- When the passive parameter is changed on an operational OSPF interface, it will be administratively disabled and re-enabled.

Refer to the *XSR CLI Reference Guide* for more information and this chapter for a sample OSPF configuration.

OSPF Troubleshooting

XSR commands provide debugging of OSPF Version 2 control information including:

- Monitoring specific OSPF events from the CLI with **`show ip ospf`** (with debugging enabled)
- Control Packets with **`debug ip ospf packet`**
- LSA transmissions/receptions with **`debug ip ospf lsas`**
- Neighbor Events with **`debug ip ospf nbr`**
- Designated Router Events with **`debug ip ospf dr`**

Be aware that only one CLI debug session is permitted at a time.

Null Interface

The XSR provides a non-configurable null interface (**`null 0`**) so that discard routes can be installed for OSPF LSA Type 3 and 5 route summarization. The null interface acts as a "bit bucket" to dispose of unwanted packets while avoiding the problem of looping.

The null interface is unlike any other XSR port in that it does not need an IP interface to be enabled - it is always up, it cannot be deleted, and it appears only when specifically referenced by the **`show ip interface null0`** or **`show interface null0`** commands. Other **`show`** commands *do not* display the port. Additionally, the null interface is characterized by the following:

- It can be specified in the **`ip route`** command as the next hop:
  `ip route 7.0.0.0 255.0.0.0 null0`
- Routes which are unreachable through **`null0`** cannot be redistributed
- It responds to the **`interfaces.ifTable.ifEntry`** SNMP query with the value 0 or as follows: **`interfaces.ifTable.ifEntry.ifDescr.7 = Null0`**

Refer to the *XSR CLI Reference Guide* for more information on commands.

Route Preference

Route preference or *administrative distance* is a tool to decide which route to install in the global routing table. Each routing protocol presents the global Routing Table Manager (RTM) with its best selection of a route. If several routes to the same destination are offered (derived from different protocols), installation occurs based on the protocol's administrative distance. The route for the *protocol with the lowest distance* is chosen from the table. The feature functions as follows:

- Administrative distance is configurable per protocol using the **`distance`** command. Static routes remain configurable per *route*.
- OSPF distance can be set for different values on intra-area, inter-area, and external routes.
- OSPF distance must follow this rule: Intra-area distance is less than inter-area distance which is less than external distance.
- Static route distance can be set using the **`ip route`** command. If distance is not specified, the default distance is applied.
- Aggregation is not accepted in order to set the distance for several static routes at one time.
- Configuring the same distance across different protocols is permitted except for multiple static routes. Tie breaks are resolved by the following default administrative distances:
  - Connected routes: *0*

  - Static routes: *1*
  - BGP external routes: *20*
  - OSPF intra-area routes: *108*
  - OSPF inter-area routes: *110*
  - OSPF external routes: *112*
  - RIP routes: *120*
  - BGP internal routes: *200*
  - Values between 241 and 255 are reserved for internal use
- The **`show ip route`** command displays distances and metrics.

Refer to the *XSR CLI Reference Guide* for more information on commands.

Static Routes

Static routes are used when a dynamic route to a destination cannot be set up or to specify what the XSR will route to. The XSR creates static routes with the **`ip route`** command. Refer to the *XSR CLI Reference Guide* for more information and sample static route configurations.

The XSR's Static Route Manager (SRM) allows configuration of multiple static routes to the *same destination* but with different hop and distance values. You can cap the number of these routes with **`ip route maximum_multiple`**.

The SRM validates and forwards all reachable static routes to the Routing Table Manager (RTM) which saves them but implements only the best (lowest distance) route. Unreachable static routes are saved in the SRM for later use should they become reachable.

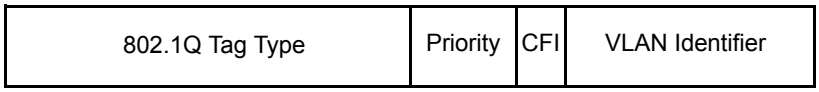
When an interface is enabled, all static routes accessible through that interface are stored in the RTM. Also, for multi-point interfaces, when a neighbor becomes accessible, all the best static routes accessible through that neighbor are saved in the RTM. Conversely, when an interface is disabled, all static routes accessible through that interface are deleted from the RTM. The same holds true on multi-point interfaces.

VLAN Routing

Virtual Local Area Networks (VLANs) allow groups of end systems, possibly on multiple physical LAN segments, to communicate as if they were a common LAN unconstrained by the network's physical layout. VLAN switches can be used to establish different broadcast domains within networks but different VLANs cannot communicate with one another through VLAN switches because routing is still required for inter-VLAN traffic. The XSR's VLAN route traffic among IEEE 802.1Q VLANs.

The IEEE 802.1Q standard documents the insertion of a VLAN tag, shown in Figure 5-1, between the Source MAC address and the Length/Type of an Ethernet frame to identify the VLAN to which the frame belongs.

Figure 5-1 802.1Q VLAN Tag



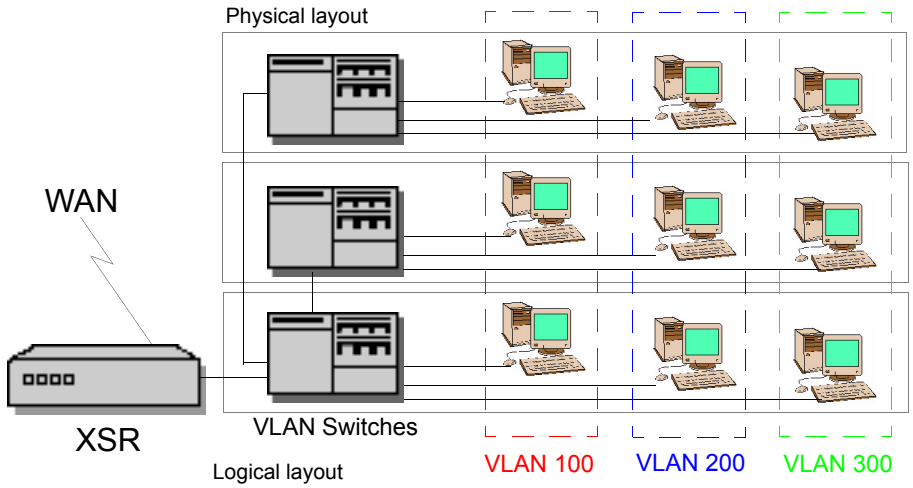
The reserved Tag Type denotes the associated Ethernet frame type of the VLAN Tag while the remaining 16 tag bits comprise this control data:

- a 3-bit value indicating the *user priority* of the Ethernet frame for QoS purposes
- a 1-bit Canonical Format Indicator (CFI) denoting the presence of a Routing Information Field
- a 12-bit VLAN Identifier (VLAN ID) used for network assignment

The XSR lets you configure up to 4094 VLANs using the **`vlan`** command, with IDs 0 and 4095 reserved. VLAN ID 0 is used to represent the default VLAN. VLANs provide for eight priority levels but the XSR does not act on priority bits. Any VLAN packets originating from the XSR are assigned a priority of 0.

Figure 5-2 depicts a typical VLAN routing setup. The LAN that a device belongs to depends on the settings of the interfaces on the VLAN switch rather than the actual systems layout.

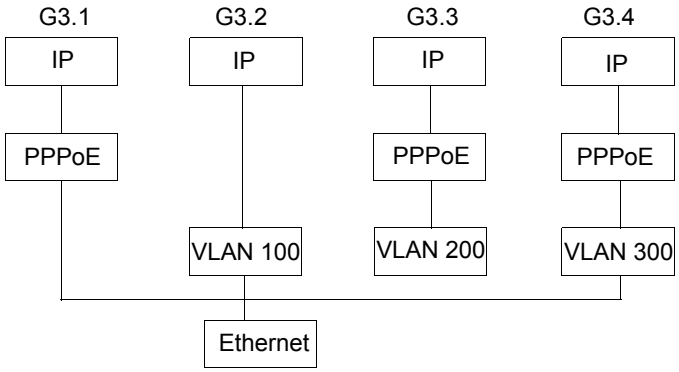
Figure 5-2 Typical Configuration of VLAN Routing



Forwarding VLAN, PPPoE over VLAN

It is possible for a single physical Ethernet interface to support a mixture of Ethernet, PPPoE, Ethernet VLAN, and PPPoE over VLAN traffic, as illustrated in Figure 5-3. Note that GigabitEthernet sub-interfaces 3.1 - 3.4 are all sub-interfaces associated with different VLAN IDs.

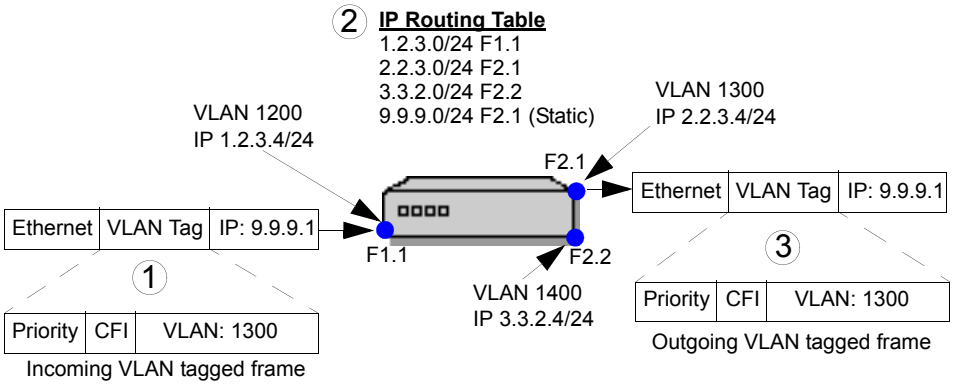
Figure 5-3 Topology of Ethernet/PPPoE/VLAN/PPPoE over VLAN



VLAN Processing Over the XSR's Ethernet Interfaces

The VLAN routing process, shown in Figure 5-4, works as follows on the XSR. The following steps are reflected in the graphic below.

Figure 5-4 XSR's VLAN Processing

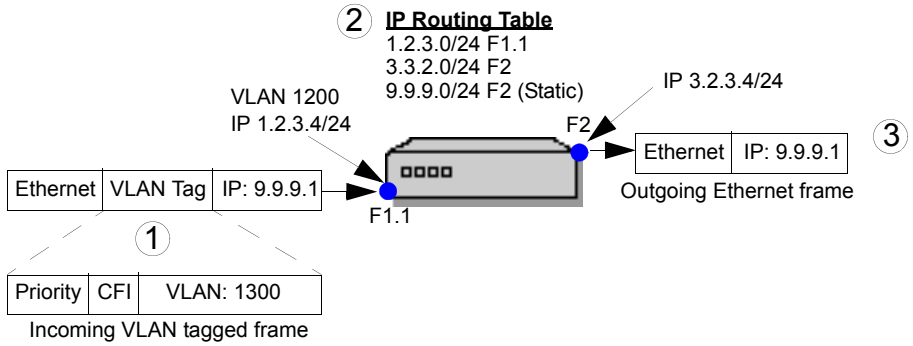


1. When a VLAN-tagged Ethernet frame is received, it is stripped and the tag's VLAN ID used to map the frame to a sub-interface of the Ethernet port. Priority bits are kept internally with the frame. If a PPPoE session header exists behind the tag, the frame is further de-muxed. The matched sub-interface is marked as the incoming port. If no match is found for the VLAN ID, the frame is dropped.
2. The Ethernet frame's IP packet is routed based on the XSR's forwarding table which chooses the next hop and outgoing interface.
3. If the outgoing interface is associated with a VLAN by a VLAN ID, a VLAN tag including the VLAN ID is created and inserted into the outgoing Ethernet frame. If priority bits are stored with the frame, they are marked in the VLAN tag.

VLAN Processing: VLAN-enabled Ethernet to Standard LAN Interfaces

In this scenario, illustrated in Figure 5-5, the XSR does not insert a VLAN tag since there is no VLAN associated with the outgoing interface.

Figure 5-5 VLAN Ethernet to Fast/GigabitEthernet Topology

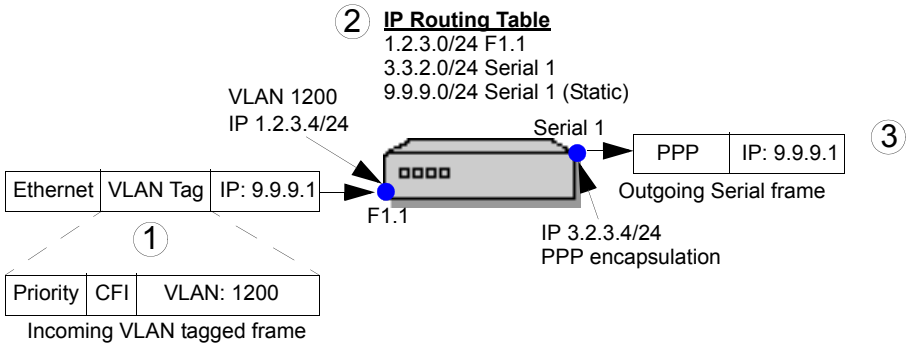


VLAN Processing: VLAN-enabled Ethernet to WAN Interfaces

In this scenario, shown in Figure 5-6, the XSR does not insert a VLAN tag in Ethernet frames because no VLAN is linked with the outgoing port (Serial 1).

Note: VLAN tags *cannot* be assigned to a WAN interface - they are relevant only for XSR FastEthernet and GigabitEthernet interfaces.

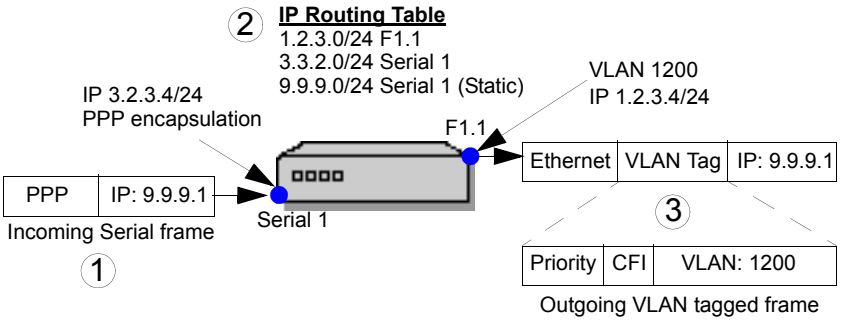
Figure 5-6 VLAN Ethernet to WAN Interfaces Topology



VLAN Processing: WAN Interface to a VLAN-enabled Ethernet Interface

In this scenario, as shown in Figure 5-7, a VLAN tag *is* inserted since a VLAN ID (1200) is associated with the outgoing VLAN sub-interface (FastEthernet 1.1). The packet will be forwarded to IP address 9.9.9.1 of the next-hop router. For traffic which did not enter the XSR from a VLAN sub-interface, the priority bits are set to 0 (lowest level).

Figure 5-7 WAN Interface to VLAN Ethernet Topology



For sample configurations, refer to "Configuring VLAN Examples" on page 5-46.

QoS with VLAN

The XSR's support for Quality of Service (QoS) with VLAN is described in the chapter "Configuring Quality of Service" on page 12-1.

Policy Based Routing

IP packets typically are forwarded according to the route chosen by traditional routing protocols RIP, OSPF, BGP or static routes. Selection is based only on the *destination* of the packet. Policy Based Routing (PBR) allows you to *selectively forward* some patterned packets through alternative paths. It is not meant to replace routing protocols but is complementary while adding flexibility. If any packets do not meet policy criteria, the destination-based routing table will be searched.

PBR is beneficial for the following reasons:

- *Flexible Transit Provider Selection* - Internet service providers and others can set priorities for their customers and use PBR to route traffic according to their users' priorities through different Internet connections across policy routers.
- *Cost Savings* - PBR can cut networking costs by distributing traffic among low-cost and high-cost paths.
- *Load Sharing* - You can implement policies to distribute traffic among multiple paths based on traffic characteristics as opposed to traditional load sharing. With PBR, the same traffic flow will go through the same path but different traffic flow will be directed over a different path according to the policy.

Note: Policy-based routing takes precedence over destination-based routing.

Accessing the Global Routing Policy Table

Policy-based routing can be applied to incoming packets only and can be enabled on any interface with the **`ip policy`** command. It works as follows:

1. If a packet is a candidate for PBR, the XSR consults a global routing policy table in the form of a *route-map t*able having multiple entries. Each entry is assigned a *sequence number* and are sequentially ordered from low to high. The **`route-map pbr`** command specifies the sequence number and acquires PBR configuration mode. You can display this information with the **`show route-map pbr`** command.

2. When a policy entry is found for a packet, the table search ends and the packet is processed according to that entry.
3. Each entry has a group of *match* and *set* clauses. All match clauses must match in order to process the packet according to the entry. When a match is found, one of the set clauses is used to process the packet. Set clauses are listed according to the order you configure them but when one clause specifies an invalid next hop or interface, the next clause is searched.

Match Clauses

Packet flows are identified by use of Access Control Lists (ACL). ACLs specify traffic to be routed according to a particular end system, higher protocol layer (UDP or TCP), or a port number within the specified protocol. The XSR associates ACLs with PBR by the **`match ip-address <acl>`** command. Multiple clauses can be configured for each policy entry.

Set Clauses

The XSR provides two ways for the policy to specify the forwarding path in the set statement:

- through the *next-hop* router with the **`set ip next-hop`** command
- through the *outgoing interface* with the **`set interface`** command

Forwarding behavior is governed by the following considerations:

- The next-hop router can be configured only if it belongs to an XSR-connected network.
- Traffic over Serial sub-interfaces can be forwarded only to the next-hop router.
- The outgoing interface need not be enabled when the entry is configured but will be disregarded when a packet is processed if still in down state.
- If a match is found but no set clause is available to forward the packet, the packet is discarded.

PBR Cache

Since ACL matching is too resource-intensive to perform for all packets, the short-cut *cache* is created based on a packet's contents. Each entry in the PBR cache contains a packet's source and destination IP address, and IP protocol number. Also a port number is kept if the IP protocol is TCP/UDP, and an ICMP code number kept for ICMP.

Data on how to forward the packet is also saved in the cache. When a packet enters the XSR, the router first searches the cache for any match on the packet. If a match is made, the packet is forwarded according to the forwarding data. If no match is found, the policy table is searched and a cache built up when forwarding information becomes available. You can view real-time PBR cache data with the **`show ip pbr-cache`** command.

When a newly created cache entry is not accessed within two to four minutes, that cache is deleted and if the next packet arrives with no cache entry matched, a new cache will be created.

For more information, refer to "Configuring Policy Based Routing Example" on page 5-44.

Default Network

The default network is used to specify candidates for the default route when a default route is not specified or learned. If the network specified by the **`ip default-network`** command appears in the routing table from any source (dynamic or static), it is flagged as a candidate default route and is subject to being chosen as the default route for the XSR.

Note: Use this command only when the default network is more than *one hop* away *and* the XSR has either a *static* or *dynamic* route to it. Do not confuse creating a valid static route of all zeroes (**`ip route 0.0.0.0 0.0.0.0 <IPaddress/next-hop>`**) with an *invalid* all-zero default network.

You may enter **`ip default-network`** multiple times. All candidate default routes appear in the routing table preceded by an asterisk. If the network specified is a subnet, default routing applies only to the classful network. If a directly connected interface is specified, RIP will generate a default route.

If the XSR has no interface on the default network but has a route to it, it will consider this network a candidate default route for itself. The best route candidate is chosen based on administrative distance and metric.

The gateway to the best default path will be named the gateway of last resort for the router. The gateway of last resort is the gateway for the route used by packets as the last possible alternative, when there is no route to the destination, including a default route.

Refer to the *XSR CLI Reference Guide* for more information and a sample default route configuration.

Classless Inter-Domain Routing (CIDR)

CIDR is an advanced address scheme for the Internet allowing more efficient allocation of IP addresses than the earlier A, B, and C address scheme. CIDR currently uses prefixes anywhere from 13 to 27 bits. This allows for address assignments that much more closely fit an organization's specific needs. CIDR addressing also enables *route aggregation* in which a single high level route entry can represent many lower-level routes in the global routing table, thus reducing the table size.

The XSR supports CIDR in all IP address/subnet mask CLI commands and the feature is always enabled. The **`ip address`** {**`address mask`** | **`address&mask`** | **`negotiated`**} command is just one CIDR-applicable command you can enter.

Note: CIDR is not supported where a reverse mask is used.

Router ID

A router identifier is used by routing protocols such as OSPF to uniquely identify a routing instance. When the Router ID is not assigned, it is selected in the following manner by the XSR:

- If loopback interfaces are configured, the Router ID is selected based on the highest IP address among active loopback interfaces.
- If no loopback are interfaces configured, the Router ID is selected based on the highest IP address among active physical interfaces.

Leaving the Router ID unconfigured or allowing it to be assigned by default to a physical IP interface can be risky because physical interfaces are impermanent and their IP addresses can be re-configured. A change in an IP address or the state of a physical interface that has been selected as the Router ID will cause the XSR to drop and recreate its neighbor adjacencies, leading to unnecessary instability.

The XSR permits you to configure the Router ID, using the **`ip router-id`** command, with the following conditions:

- The configured Router ID IP address need not correspond to a valid interface (loopback or physical).
- When the Router ID is changed, dependant protocols (i.e., OSPF) are informed and the protocol restarted with the new Router ID.
- Precedence for Router ID selection is: *user-configured* Router ID, then highest IP address *loopback* port, and highest IP address *physical* port.

Real Time Protocol (RTP) Header Compression

RTP header compression is useful for VoIP traffic over low speed PPP wan links . For VoIP packets, the 40 bytes of header (IP header + UDP + RTP header) is almost as large as the VoIP payload itself. The ability to reduce the header size enables more voice traffic to be passed over the PPP wan link.

RFC 2508 describes a scheme where the 40 byte combined header of RTP (VoIP) traffic can be reduced to 2 to 4 bytes under most circumstances.

With release 7.6.0.0, the XSR now supports both the VJ Header Compression (for TCP and UDP header) and the new IP Header Compression (for TCP, UDP and RTP header compression).

XSR cannot be configured to initiate VJ header compression, but it does response to VJ Header compression configuration option from the remote peer with a NAK or REJ.

In release 7.6.0.0, the behavior is changed slightly. If RTP is not enabled, then upon receiving a VJ header compression negotiation option, the XSR sends back a NAK or REJ, same as in current release.

XSR uses the following criteria to select packets for RTP compression:

Must be UDP packet,

UDP payload must be less than 500 bytes,

Packet must not be fragmented, and

The destination port of the packet must be within user configurable port range (there is no restriction on the source port). The XSR does not impose any restriction on RTP de-compression.

The following new alarms are added for RTP header compression:

High Severity alarm:

Out of memory, RTP compression disabled

Low Severity alarms:

RTP_compression RX failed allocate memory

RTP_compression TX reached maximum allowed connections,

RTP compression received un-expected 8 bit CID

RTP compression received un-expected 16 bit CID

Received CID (mmm) exceeds the negotiated max CID nnn.

Network Address Translation

Network Address Translation (NAT) maps IP address from one address realm to another, providing transparent routing to end hosts. Using NAT and Network Address Port Translation (NAPT), the protocol provides a way for many users to share one global IP address. NAT also enhances access security by only allowing certain global addresses to access the private network.

NAT is limited in some respects: it requires more processing in the fast path which can impact packet delivery speed. Also, applications which bundle the host IP address inside the payload do not interoperate with NAT because the address does not match the address on the IP header.

A special translation agent known as an Application Level Gateway (ALG) is used to allow such programs on a host in one address realm to transparently connect to its counterpart running on a host in a different realm.

The XSR implements traditional NAT (RFC-3022). It has two forms:

- *Static NAT* - Hosts on the private network are mapped statically to global addresses. There are two kinds of basic NAT:
  - *One-to-one mapping* - Each host is supplied a one-to-one mapping, on the private network, to a global address. Hosts without mappings are not NATted.
  - *Pool mapping* - A pool of global addresses is defined. Hosts on the private network are mapped to global addresses on a first-come, first-serve basis. Once a global address is selected, static mapping is performed. This NAT type is not supported at this time.
- *NAPT* - Both the source address and source port of hosts on the private network are translated. The global address is that of the egress interface. Hosts on the private network all share the same global address (based on the egress interface).
  - *Pool NAT* -
  - *Pool NAT with Overload* -

Note: Prioritization of packets passing from trusted to external interfaces for the XSR's four basic types of NAT are, in descending order:
• Interface Static NAT
• Global Static NAT
• Pool NAT
• NAPT

Features

The following NAT features are supported on the XSR:

- Static NAT - One-to-one mapping based on global (independent of interface) static mapping table. Mapping is permanent and is deleted only if the configuration is removed.
- Network Address Port Translation (NAPT).
- Standard and Extended Access Control Lists supported.

- Application Level Gateway (ALG) for FTP, ICMP, Netbios over TCP and UDP
  - PPTP/GRE ALG for NAPT - allows PPTP traffic to be NATted
- Multiple ISP - NAPT based on the egress interface.
- With NAPT, routing is not automatically filtered out. Use distribution lists to ensure global networks are advertised out of external ports.
- NAT configuration for VPN interfaces.
- Pool NAT (without NAPT).
- Pool NAT with overload - Each address allocated from the pool is used to perform NAPT. When all ports are exhausted, the next address is allocated.
- NAPT with an arbitrary IP address - Any arbitrary IP address can be utilized for NAPT in addition to the interface IP address.
- Interface-specific static NAT - Static NAT is employed on an interface so that only packets that leave/enter that external interface are NATted.
- Port Forwarding - Interface-static NAT is used for port forwarding. When NAPT is configured and an incoming packet does not have a translation entry, interface static NAT will select the private IP address and port based on the packet's destination port.
- Multiple NATs on an interface - Multiple pool NATs with ACLs, static NAT and NAPT are supported on an interface simultaneously with the NAT type used in the order it is specified.
- IPSec support
  - Out-bound packets are processed first by NAT, then forwarded to IPSec for encryption.
  - In-bound packets are processed by NAT after IPSec decryption.

Fore more information, refer to "Configuring NAT Examples" on page 5-38.

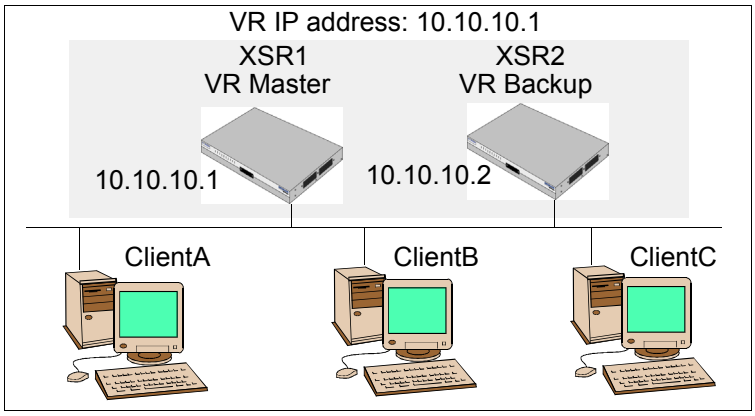
Virtual Router Redundancy Protocol

The Virtual Router Redundancy Protocol (VRRP) provides redundancy and load sharing of multiple IP default gateways on a single LAN without requiring that LAN's hosts to run a routing protocol. VRRP configures multiple IP routers on one broadcast LAN to form a single Virtual Router (VR), which has both a unique virtual IP and virtual MAC address.

The advantage of this protocol is that hosts on a LAN can switch from one IP router to another (in case of failure) without changing their routing configuration or running additional protocols. Load balancing can also be implemented by configuring multiple VRRP routers across multiple IP routers, with each IP router being the master of a different virtual router.

VRRP is an alternative to dynamic types of router discovery such as proxy ARP, RIP and IRDP in that it specifies a group of statically configured default gateways on the client. For example, Figure 5-8 below shows a LAN topology where XSRs 1 and 2 are VRRP routers (running VRRP) comprising one virtual router (VRRP group). The IP address of the VR matches that of the Ethernet interface of XSR1 (10.10.10.1).

Figure 5-8 Simple VRRP Topology



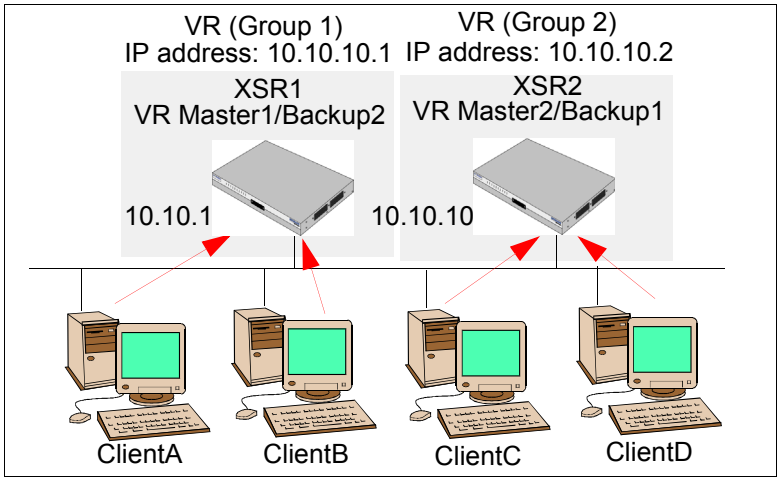
Because the VR uses the IP address of the physical Ethernet interface of XSR1, XSR1 becomes the *master VR*, also known as the *IP address owner*. XSR1, as the master VR, assumes the IP address of the VR and is responsible for forwarding packets sent to this IP address.

Clients A, B, and C are configured with the default gateway IP address of 10.10.10.1.

XSR2 is a backup VR. If the master VR fails, XSR2 will take over as the master VR and support the connected LAN hosts. When XSR1 comes back on line, it assumes the role of master VR again.

Figure 5-9 illustrates a topology where VRs XSR1 and XSR2 split outgoing traffic between them and provide full system redundancy. ClientA and ClientB install a default route to XSR1's VR IP address and ClientC and ClientD install a default route to XSR2's VR IP address. Both XSRs serve dual master/backup roles.

Figure 5-9 Load Balanced, Redundant VRRP Topology



VRRP Definitions

The XSR defines VRRP terms as follows:

- *VRRP Router* - A router running the Virtual Router Redundancy Protocol. It may participate in one or more VRs.

- *Virtual Router* - An abstract object managed by VRRP that acts as a default router for hosts on a shared LAN. It consists of a VR Identifier and a set of associated IP address(es) across a common LAN. A VRRP router may back up one or more VRs.
- *IP Address Owner* - The VRRP router that has the VR's IP address(es) as real interface address(es). This is the router that, when up, will respond to packets addressed to one of these IP addresses for ICMP pings, TCP connections, etc.
- *VRRP Primary IP Address* - An IP address selected from the set of real interface addresses. One possible selection algorithm is to always select the first address. VRRP advertisements are always sent using the primary IP address as the source of the IP packet.
- *Virtual Router Master* - The VRRP router that assumes the responsibility of forwarding packets sent to the IP address(es) associated with the VR, and answers ARP requests for these IP address. Note that if the IP address owner is available, then it will always become the master.

How the VRRP Works

Multiple IP routers on a single broadcast LAN comprise a single virtual router, which has a unique virtual IP address and virtual MAC address. Hosts on the LAN configure the VR as their default router (default gateway). Devices that provide support for a VR form a *VRRP group*. The device acting as the VR is designated the *master* of the group.

At any one time, only one of the routers acts as the VR, forwarding packets from hosts on the LAN. If that router goes down, the VRRP provides a method by which one of the other routers in the group can take over the virtual IP address and MAC address in a timely manner.

When the VRRP is started, the IP router sends and receives VRRP advertisements until a master is chosen. If the IP router does not become the master, it continues to listen to advertisements from the master of the group.

If the IP router becomes the master of the group, it begins sending VRRP advertisements and adds VRRP group information to the interface set. Once added, any Ethernet frame for the virtual MAC address is received by the IP router. Any ARP requests for the virtual IP address are responded to using the virtual MAC address.

If the IP router ceases to be the group master, it removes the VRRP group information from the system and continues to listen for VRRP advertisements from the new master.

Different States of a VRRP Router

Underlying how VRRP operates are three states the VRRP router experiences: initialize, backup, and master. *Initialize,* the first state, involves these steps:

- A VRRP router checks the virtual IP address to learn if it is the master.
- If it owns that address, it realizes it is the master and its priority is 255.
- If the priority equals 255, the VRRP router advertises itself as the master, broadcasts an ARP message to all IP addresses associated with the VR's IP address, starts the advertisement timer and transitions to the master state.
- If priority is less than 255, the VRRP router transitions to backup state.

In the *backup* state, a VRRP router monitors the VR master to confirm it is alive, does not respond to ARP requests or accept packets for the IP address(es) associated with the VR, and discards packets destined for the VR's MAC address. If an advertisement is received that the priority equals 0, then the VRRP router performs the following:

- Advertises that it is the master VR,

- Broadcasts an ARP message with the VR's MAC address to all the IP addresses associated with the VR's IP address,
- Starts the advertisement timer,
- And transitions to the master state.
- If an advertisement is received that has a higher priority, or a higher IP address (if the priority is the same), then the VRRP router discards the advertisement and remains as the master VR.

In the *master* state, a VRRP router performs as follows:

- Responds to ARP requests or accepts packets for the IP address(es) associated with the VR,
- Does not accept packets address to the IP address associated with the VR if it is not the owner of the IP address,
- Forwards packets destined for the VR's MAC address.

If a shutdown event is received, the VRRP router advertises a 0 priority.

If an advertisement with a greater priority or higher IP address (if the priority is the same) is received by the virtual master, it experiences the following:

- Transitions to a backup state
- Cancels the advertisement timer

If an advertisement is received with the priority lower than local priority, or with a lower IP address if the priority is the same, then the VRRP router discards the advertisement.

VRRP Features

Multiple Virtual IP Addresses per VR

The XSR permits specifying multiple virtual IP addresses on the VR (up to 11) to support multiple logical IP subnets on a LAN segment. Functionality is set by the **`vrrp <group> ip`** command.

The primary physical IP address in that interface will be selected as a VRRP primary IP address, which is used for the VRRP advertisement. The advertisement timer is set using the **`vrrp <group> adver-int`** command.

If one of the virtual IP addresses of a VR is the real physical address of the interface, then all other virtual IP addresses of that VR must also be the real physical addresses of that interface. Obversely, if any of the virtual IP addresses is *not* the real physical address of that interface, then all of the virtual IP address of that VR *cannot* be the real physical address of that interface.

Multiple VRs Per Router

The XSR supports multiples VRs per router as follows:

- A maximum of four VRs are supported per router.
- The scope of a VR is limited to a single LAN segment.
- The VR ID can be reused in a different scope.

Authentication

The XSR supports one type of authentication - simple password authentication - which is meant to avoid careless misconfiguration, not provide security. It is invoked with the **`vrrp <group> authentication`** command. Authentication is set per VR.

Load Balancing

The XSR provides load balancing according to the following rules:

- Load balancing depends on how your network is designed.
- Load balancing is supported by separate physical VRRP routers and not supported on the same physical router which has two LAN ports on the same LAN segment with the same subnet.

ARP Process on a VRRP Router

Three types of ARP requests can be employed on a VRRP router: *Host*, *Proxy* and *Gratuitous* ARP.

Host ARP

Host ARP performs according to the following rules:

- When a host sends an ARP request for one of the VR IP addresses, the master VR returns the virtual MAC address (00-00-5e-00-01-VRID).
- The backup VR must not respond to the ARP request for one of the VR IP addresses.
- If the master VR is the IP address owner, when a host sends an ARP request for this address, the master VR must respond with the *virtual* MAC address, not the real *physical* MAC address.
- For other IP addresses, the VRRP router must respond with the real physical MAC address, regardless of master or backup.

Proxy ARP

- If Proxy ARP is used on a VRRP router, then the master VRRP router must advertise the VR MAC address for the VR IP address in the proxy ARP message.

Gratuitous ARP

Gratuitous ARP behaves in the following manner on a VRRP router:

- Each VR sends gratuitous ARP when it becomes the master with virtual IP and MAC addresses. One gratuitous ARP is issued per VR IP address.
- To make the bridge learn the correct VR MAC address, the VR masters send gratuitous ARP for every virtual IP address in the corresponding VR every 10 seconds.

Traffic Process on a VRRP Router

Incoming traffic on a VRRP router is governed by the following rules:

- Whether a VRRP router is in a master or backup state, it must receive packets with a real physical MAC address as the destination MAC address.
- The master VR must receive packets with a virtual MAC address as the destination MAC address.
- The backup VR must not receive any packets with the virtual MAC address as the destination MAC address.

Outgoing traffic on a VRRP router is governed by the following rules:

- *Master VR* - all traffic, including locally generated or forwarding traffic, uses one of the virtual MAC addresses as the source MAC address except VRRP protocol packets, which use the corresponding virtual MAC address as the source MAC address. For example, if four VRs occupy one interface, two are in a master and the others a backup state. The VRRP router uses one of the virtual MAC addresses of the master VRs as the source MAC address for all traffic transferring over this interface, except VRRP protocol packets, which use the corresponding virtual MAC address as the source MAC address.
- *Backup VR* - all traffic will use a real physical MAC address as the source MAC address. For example, If there are two VRs on one interface and both are in the backup state. The VRRP router will use the real physical MAC address of this interface as the source MAC address for all traffic transferred over this interface.

ICMP Ping

RFC-2338 specifies that a VR master that is not the actual address owner should not respond to an ICMP ping associated with the virtual IP address. The **vrrp <group> master-respond-ping** command allows the VR master to respond to a ping regardless of actual IP address ownership.

Interface Monitoring

This feature, invoked by **vrrp <group> track**, allows a different router to act as the default gateway when a route through the local router is unavailable. An interface of a VR (usually the intended master of the VR) is set to monitor another interface on the same router, and will refrain from acting as the master of the VR if the monitored interface is down. It lowers its VR priority to 0 when the XSR meets one of the following conditions:

- The monitor interface does not exist. This occurs when you configure one monitor interface on a certain VR but do not create that interface.
- The monitor interface is removed. This occurs you remove one port which has been configured as the monitor port on a certain VR.
- The monitor interface fails. This occurs in the following cases:
  - You change the administrate state of the interface to down.
  - You remove the IP address of that interface.
  - The physical layer of the interface fails due to a disconnected cable, for example.
  - The link layer of the interface fails, such as a PPP or FR link.

The VR will increase its priority back to the original value, and may become the Master VR again if preemption is enabled, when the router meets all of the following conditions:

- The physical layer of the monitor interface comes up.
- The link layer of the monitor interface comes up.
- You configure a valid IP address for the monitor interface.
- You change the administrate state of the monitor interface to up.

When the monitored interface comes up again, the interface of the VR will increase its priority back to the original value, and may become the master VR again if preemption is enabled with **vrrp <group> preempt**. You can manually set the VR priority level with **vrrp <group> priority**.

When the actual IP address owner of the Virtual IP address releases the master state of the VR, it will no longer be able to receive any IP packet destined for that address even though the actual interface is still up.

This may cause routing packets to not reach this interface and cause this interface to be considered down by other routers. To avoid this situation when using Interface Monitoring, be sure that you configure Virtual IP addresses different than the actual IP addresses of the interfaces.

Watch Group Monitoring

This feature, entered by the **`vrrp <group> track <watch-group>`** command, permits tracking of Dialer, Fast/GigabitEthernet, Multilink or Serial interfaces or sub-interfaces. It also allows the tracking of one or more routes as configured by the **`dialer watch-list`** command. Watch lists are particularly useful for monitoring Dialer backup lines.

Watch group monitoring is very similar to interface monitoring. The VR configured with the **`dialer watch-group`** command will monitor the routes configured under the corresponding dialer watch-list instead of the interface. If all routes are not available, the VR will lower its priority to 0 and let the other router to take over as master for that VR. Usually, dialer watch-group monitoring should be configured on the XSR which has a very high likelihood of being the master for that VR.

The VR will lower its priority to 0 when the XSR meets all of the following conditions:

- All active routes configured under the corresponding dialer watch-list went down.
- The *connect* or *route check* timer has expired. Those timers can be configured under that dialer watch list. The default value for the connect timer is 5 seconds, and 30 seconds for the route check. For more timer details, refer to the *XSR CLI Reference Guide*.

The VR will increase its priority back to the original value, and may become the master VR again if preemption is enabled, when the XSR meets one of the following conditions:

- At least one of the routes configured under monitoring watch-group came up and the disconnect timer has expired. The disconnect timer can be configured under that dialer watch list with a default value of five seconds.
- You have removed the watch-list. The watch-list behaves differently on an interface: removing an interface indicates the interface is down and cannot pass traffic, but removing the watch-list indicates you do not want to monitor those routes; it does not indicate the routes configured under that watch-list are down.

When the actual IP address owner of the Virtual IP address releases mastery of the VR, it can no longer receive any IP packet destined for that address even though the actual interface is still up. This may cause routing packets to not reach this interface and cause it to be considered down by other routers. To avoid this situation, when dialer watch-group Monitoring is enabled, the Virtual IP address configured should be different from the actual IP addresses of the interfaces.

Physical Interface and Physical IP Address Change on a VRRP Router

The VR will change to the *initialize* state regardless of the interface state, if you configure a VR before configuring the physical IP address, and there will be a conflict between the physical IP and VR IP address.

Equal-Cost Multi-Path (ECMP)

Equal-Cost Multi-Path (ECMP) is a technique to forward packets along multiple paths of equal cost, aggregating multiple physical links into one virtual link to effectively increase the total bandwidth of a connection. Internally, the XSR decides which next hop to use in the event that more than one choice is available in the forwarding table and by searching this table, the forwarding engine identifies paths by the next hop.

The XSR offers two methods to calculate the next hop, described as *round robin* (per packet) and *per-flow* options in the **`ip equal-cost multi-path {round-robin | per-flow}`** command. They are characterized as follows:

- Per packet round robin - This selection method has the advantage of bearing very little impact on performance and not requiring much time for computation as well as offering perfect load balancing. Disadvantages include disruptions caused by flow-based traffic; a variable path MTU where the overall path MTU might change on a packet-by-packet basis, thus negating the usefulness of path MTU discovery; variable latencies with negative implications on TCP traffic, where packets might be received out of order; and less reliable debugging utilities (ping, traceroute) which may produce wrong results.
- Per flow round robin - this selection method is nondisruptive and lends itself to session-based traffic. It configures all packets belonging to a certain flow (as determined by source/destination IP address and protocol number) to take the same path and directs each new flow toward the next available next hop. Disadvantages include a possible detrimental impact on performance depending on the algorithm selected and unbalanced traffic flows owing to the nature of the method.

ECMP is enabled globally so it applies to static, BGP and OSPF routes as well as all interfaces. If enabled, a maximum of three paths is allowed to a particular destination. If ECMP is disabled, one path to a particular destination is permitted.

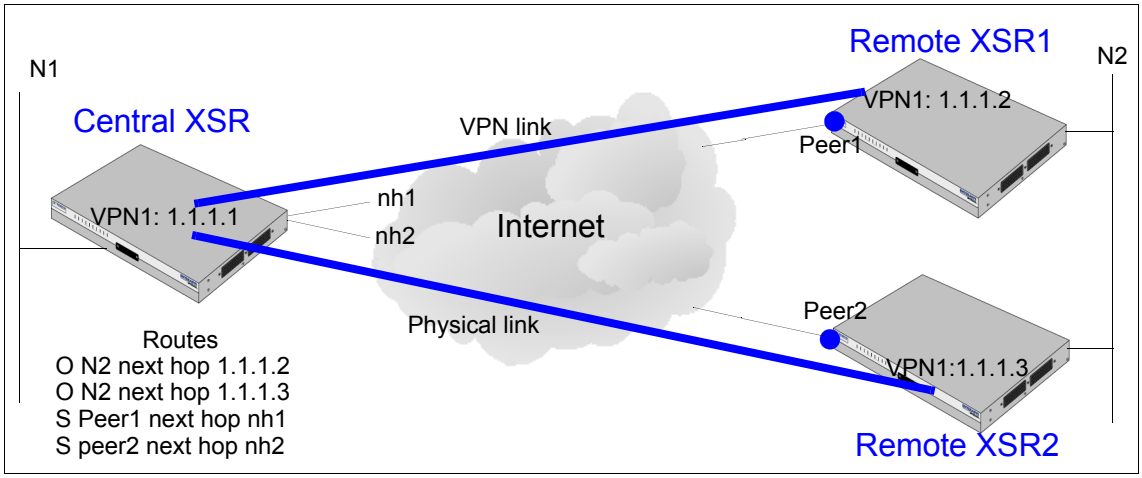
You can display configured equal cost routes by using the **`show ip route`** command which describes *routing descriptor blocks*, with one for each route. An asterisk placed (*) next to a block entry corresponds to the active route used for new traffic.

Configuration Considerations

When configuring ECMP on the XSR, keep in mind the following considerations:

- We highly recommend you employ ECMP over similar physical interfaces. If you enable *round-robin* ECMP over dissimilar physical links and those link speeds differ, results might be unpredictable because the order of incoming packets may be reversed. If you enable *per-flow* ECMP in this instance, packet order will not be a problem but balancing will be inefficient.
- The XSR supports ECMP over VPN but without tunnel balancing in circumstances where two or more tunnels *share the same peer* at equal cost. For example, ECMP is *not* supported if two tunnels are created from a remote XSR to a central XSR, each through different ISPs, with both tunnels sharing the same peer.
- The XSR does support load balancing in a VPN topology where an ECMP route is configured on an XSR to *different peers*, as shown in Figure 5-10. On the *Central* XSR, next hops *1.1.1.2* and *1.1.1.3* are selected as the ECMP route through the *VPN1* interface and static routes are configured over FastEthernet interfaces to *Peer1* and *Peer2*. In this scenario, dual levels of routing are performed: one at the virtual interface level where ECMP applies and two, at the physical interface level where static routes are used.

Figure 5-10 ECMP VPN Load Balancing Topology



Configuring RIP Examples

The following example enables RIP on both FastEthernet interfaces and a serial link of the XSR. The FastEthernet 2 interface is configured to be totally passive (updates not sent or received).

The serial interface uses *split horizon* with *poison reverse* while the others use split horizon (the default). Authentication mode text is used on Serial 1/0, and the key string is *Mexico*:

```
XSR(config)#interface fastethernet 1
XSR(config-if<F1>)#ip address 192.168.1.1 255.255.255.0
XSR(config-if<F1>)#no shutdown

XSR(config)#interface fastethernet 2
XSR(config-if<F2>)#no shutdown
XSR(config-if<F2>)#ip address 192.169.1.1 255.255.255.0

XSR(config)#interface serial 1/0
XSR(config-if<S1/0>)#ip address 192.5.10.2 255.255.255.0
XSR(config-if<S1/0>)#ip split-horizon poison
XSR(config-if<S1/0>)#ip rip authentication key-string Mexico
XSR(config-if<S1/0>)#ip rip authentication mode text
XSR(config-if<S1/0>)#encapsulation ppp
XSR(config-if<S1/0>)#no shutdown

XSR(config)#router rip
XSR(config-router)#network 192.168.1.0
XSR(config-router)#network 192.169.1.0
XSR(config-router)#network 192.5.10.0
XSR(config-router)#passive-interface fastethernet 2
XSR(config-router)#no receive-interface fastethernet 2
```

The following RIP example sets an Access Control List (ACL) to allow packets from the address of 192.168.1.*xxx* and 154.68.1.*xxx* (where *xxx* are any valid numbers) only through the XSR's F1 port.

```
XSR(config)#interface FastEthernet 1
XSR(config-if<F1>#no shutdown
```

```
XSR(config-if<F1>)#ip address 192.168.1.100 255.255.255.0
XSR(config-if<F1>)#ip access-group 1 in
XSR(config-if<F1>)#ip access-group 1 out

XSR(config)#interface serial 1/0
XSR(config-if<S1/0>)#no shutdown
XSR(config-if<S1/0>)#media-type V35
XSR(config-if<S1/0>)#encapsulate ppp
XSR(config-if<S1/0>)#ip address 154.68.1.47 255.255.255.0

XSR(config)#router rip
XSR(config-router)#network 154.68.1.0
XSR(config-router)#network 192.168.1.100
XSR(config)#access-list 1 permit 192.168.1.0 0.0.0.255
XSR(config)#access-list 1 permit 154.68.1.0 0.0.0.255

XSR#copy running-config startup-config
```

The following configuration sets up RIPv1 with Dynamic Host Configuration Protocol (DHCP) Relay enabled. DHCP relay is used when no DHCP server exists on the immediate network.

When a local client sends a DHCP request, the XSR relays this request to the appropriate DHCP server specified by the *helper-address*. After the server responds, the XSR relays this response back to the local client. As described below, the XSR connects to the PSTN via a T1 connection with 12 associated channels comprising *channel-group 0*. This T1 channel group is presented to the XSR as a serial port and is configured similarly.

The T1 (serial port) connection is unnumbered, indicating packets from the T1 interface will use the IP address of the Ethernet interface instead of its own.

```
XSR(config)#controller t1 0/2/0
XSR(config-controller<T2/0>)#channel-group 0 timeslots 1-12
XSR(config-controller<T2/0:1-12>)#no shutdown

XSR(config)#interface fastethernet 1
XSR(config-if<F1>)#no shutdown
XSR(config-if<F1>)#ip address 192.168.1.100 255.255.255.0
XSR(config-if<F1>)#ip helper-address 154.68.1.1

XSR(config-if<F1>)#interface serial 2/0:0
XSR(config-if<S2/0:0>)#no shutdown
XSR(config-if<S2/0:0>)#encapsulate ppp
XSR(config-if<S2/0:0>)#ip unnumbered fastethernet 1

XSR(config)#router rip
XSR(config-router)#network 192.168.1.100
XSR#copy running-config startup-config
```

Configuring Unnumbered IP Serial Interface Example

The following example configures an X.21-type, serial interface 1/0 as an unnumbered serial interface. Serial 1/0 is directed to use the IP address of FastEthernet port 1.

```
XSR(config)#interface fastethernet 1
XSR(config-if<F1>)#ip address 192.168.1.1 255.255.255.0
XSR(config-if<F1>)#no shutdown

XSR(config)#interface serial 1/0
XSR(config-if<S1/0>)#media-type x21
XSR(config-if<S1/0>)#encapsulation ppp
XSR(config-if<S1/0>)#ip unnumbered fastethernet 1
XSR(config-if<S1/0>)#no shutdown

XSR#copy running-config startup-config
```

Configuring OSPF Example

The following is a sample configuration of OSPF which adds three networks to OSPF areas including stub and NSSA areas, sets the retransmit interval on interface FastEthernet 1 to 9 seconds, specifies the cost of sending traffic on interface Serial 1/0 to 64, and redistributes static routes into OSPF:

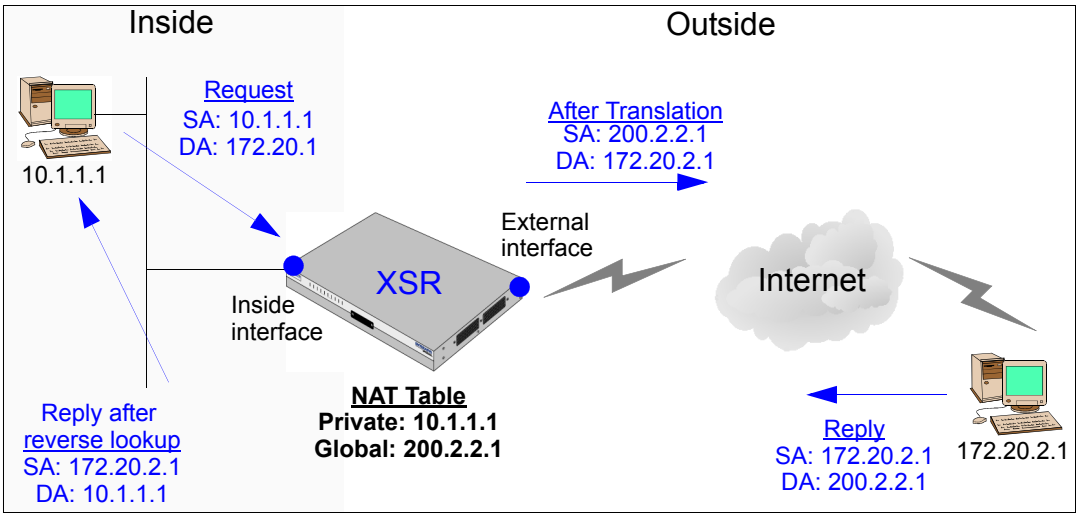
```
XSR(config)#interface FastEthernet 1
XSR(config-if<F1>)#no shutdown
XSR(config-if<F1>)#ip address 192.168.1.100 255.255.255.0
XSR(config-if<F1>)#ip ospf retransmit-interval 9
XSR(config-if<F1>)#interface FastEthernet 2
XSR(config-if<F2>)#no shutdown
XSR(config-if<F2>)#ip address 156.57.99.3 255.255.255.0
XSR(config)#interface serial 1/0
XSR(config-if<S1/0>)#no shutdown
XSR(config-if<S1/0>)#media-type V35
XSR(config-if<S1/0>)#encapsulation ppp
XSR(config-if<S1/0>)#ip address 154.68.1.47 255.255.255.0
XSR(config-if<S1/0>)#ip ospf cost 64

XSR(config)#router ospf 1
XSR(config-router)#network 192.168.1.0 0.0.0.255 area 0.0.0.10
XSR(config-router)#network 154.68.1.0 0.0.0.255 area 0
XSR(config-router)#area 10 nssa default-information-originate
XSR(config-router)#network 156.57.99.3 255.255.255.0 area 1
XSR(config-router)#area 1 stub
XSR(config-router)#redistribute static

XSR#copy running-config startup-config
```

Configuring NAT Examples

Basic One-to-One Static NAT

The following example illustrates inside source address translation on the XSR, as shown in Figure 5-11 below.

Figure 5-11 NAT Inside Source Translation



1. The user at 10.1.1.1 opens a connection to host 172.20.2.1.
2. The first packet the XSR receives from host 10.1.1.1 causes the router to check its NAT table.
   - If a static entry was configured, the XSR proceeds to Step 3.
   - If no translation entry exists, the router decides that 10.1.1.1 must be translated dynamically, selects a global address from the dynamic address pool, and creates a translation entry.
3. The XSR replaces the inside local source address of 10.1.1.1 with the global IP address 200.20.2.1 and forwards the packet.
4. Host 172.20.2.1 receives the packet and responds to IP address 200.20.2.1.
5. The XSR receives the packet with the inside global destination IP address 200.20.2.1, it looks in the table, and translates the destination address to the inside local destination address 10.1.1.1. Then it forwards the packet to 10.1.1.1.

Configuring Static Translation

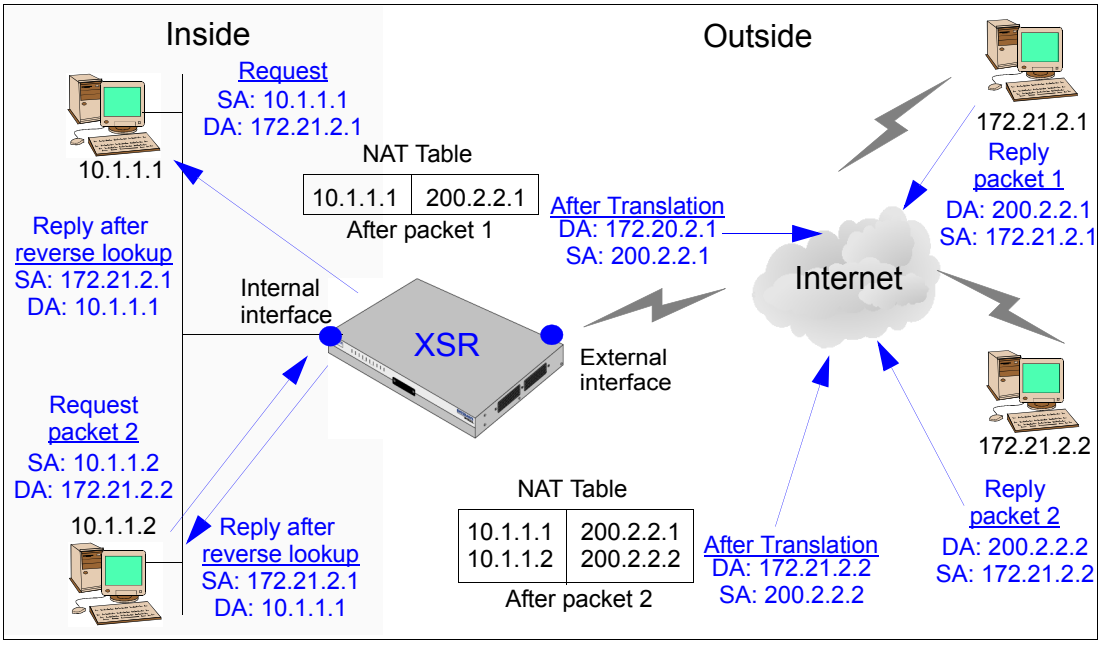
Only one command is required to configure NAT because static NAT is interface independent. Optionally, you can configure multiple entries in the static translation table with the **`ip nat source static`** command.

- XSR(config)#ip nat source static local-ip global-ip
  + Sets the static translation

Dynamic Pool Configuration

The following example illustrates dynamic pool translation on the XSR, as shown in Figure 5-12.

Figure 5-12 Dynamic Pool Translation



Configuring Dynamic Pool Translation

Dynamic pool translation, as shown in Figure 5-12, is performed through the following process:

1. The user at address 10.1.1.1 opens a connection to address 172.21.2.1
2. The first packet that the XSR receives from address 10.1.1.1 forces a NAT Pool table check. If no dynamic pool entry exists, and address 10.1.1.1 must be translated, then the XSR adds a pool entry. The router replaces the inside local address 10.1.1.1 with the inside global address 200.2.2.1, and forwards the packet. Any other connections originating from address 10.1.1.1 will use address 200.2.2.1 as the global address.
3. Host address 172.21.2.1 receives the packet, and responds to address 10.1.1.1 by using the inside global address 200.2.2.1.
4. When the XSR receives the packet, it searches its NAT Pool table, using address 200.2.2.1, translates the address to inside local address 10.1.1.1, and forwards it to address 10.1.1.1.
5. The same process applies to the connection originating from address 10.1.1.2, but a different global IP address is used.

Now enter the commands below to set dynamic pool translation. Note some steps are optional.

1. Create local IP pool *NATpool* with excluded IP addresses (optional) and quit Local Pool mode:

```
XSR(config)#ip local pool NATpool 200.2.2.0 255.255.255.0
XSR(ip-local-pool)#exclude 200.2.2.1 8
XSR(ip-local-pool)#exclude 200.2.2.21 233
XSR(ip-local-pool)#exit
```

2. Register the global NAT pool:

```
XSR(config)#ip nat pool NATpool
```

3. *Optional*. Add an ACL to permit NAT traffic from the 10.1.1.0 network. All other traffic is implicitly denied.

   ```
   XSR(config)#access-list 57 permit 10.1.1.0 0.0.0.255
   ```

4. *Optional*. Reset the default NAT timeout interval to 5 minutes:

   ```
   XSR(config)#ip nat translation timeout timeout 300
   ```

5. Enable an interface; F1, for example:

   ```
   XSR(config)#interface fastethernet 1
   ```

6. Bind the interface and optional ACL to the NAT pool:

   ```
   XSR(config-if<F1>)#ip nat source list 57 pool NATpool
   ```

7. *Optional*. Enable a second interface, F2, to use the same NAT pool:

   ```
   XSR(config)#interface fastethernet 2
   ```

8. *Optional*. Bind the second interface to *NATpool*:

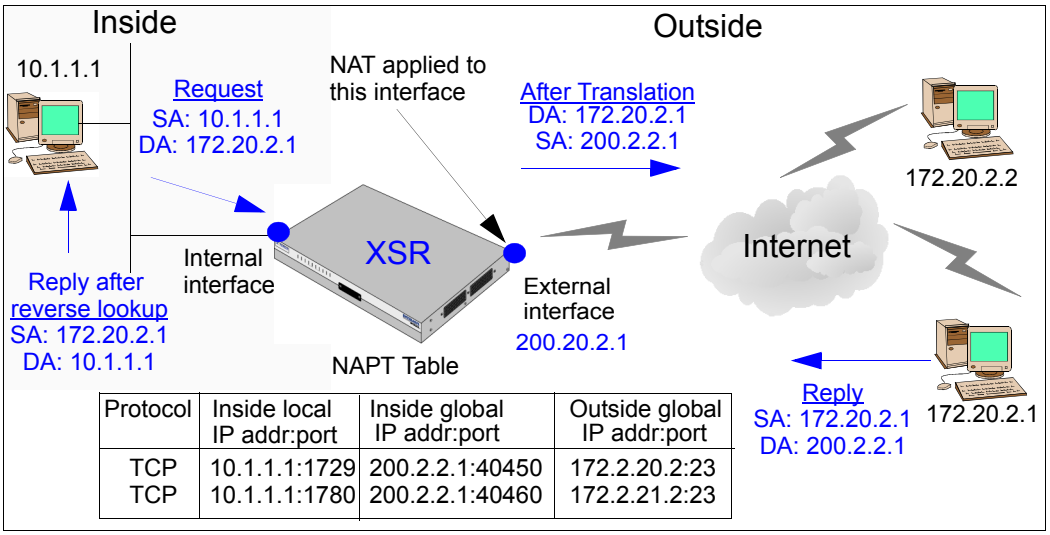
   ```
   XSR(config-if<F2>)#ip nat source pool NATpool
   ```

Note that no ACL is associated with *NATpool*. Alternatively, you can create a second NAT pool which will share addresses with the first configured NAT pool.

Network Address and Port Translation

This example sets inside source address translation with overload (NAPT) XSR (Figure 5-13).

Figure 5-13 NAT Inside Source Translation with Overload (NAPT).



Protocol	Inside local IP addr:port	Inside global IP addr:port	Outside global IP addr:port
TCP	10.1.1.1:1729	200.2.2.1:40450	172.2.20.2:23
TCP	10.1.1.1:1780	200.2.2.1:40460	172.2.21.2:23

Configuring NAPT

Inside source address translation with overload, as shown in Figure 5-13, is configured as follows:

1. The user at address 10.1.1.1 opens a connection to host address 172.20.2.1.
2. The first packet that the XSR receives from 10.1.1.1 prompts a check of the NAPT table. If no translation entry exists and the address 10.1.1.1 must be translated, the XSR sets up a translation entry. So the router replaces the inside local address 10.1.1.1 with the external address 200.20.2.1, replaces the source port with 40450, and forwards the packet.

3. Host 172.20.2.1 receives the packet and responds to address 200.2.2.1.
4. When the XSR receives the packet, it searches the NAPT table, using the protocol, global address and port, and translates the address to the inside local address 10.1.1.1 and destination port 1789, then forwards it to address 10.1.1.1.

Configuring NAPT

Enter the following commands to configure overloading of inside global addresses. This example configures an optional access list to permit specified traffic. All other traffic is implicitly denied.

```
XSR(config)#interface serial 1/0
```

+ Configures serial port and acquires Interface mode

```
XSR(config-if<S1/0>)#ip nat source list 99 assigned overload
```

+ Specifies NAT translation rules on the interface

```
XSR(config)#access-list 99 permit ip 10.1.1.0 0.0.0.255
```

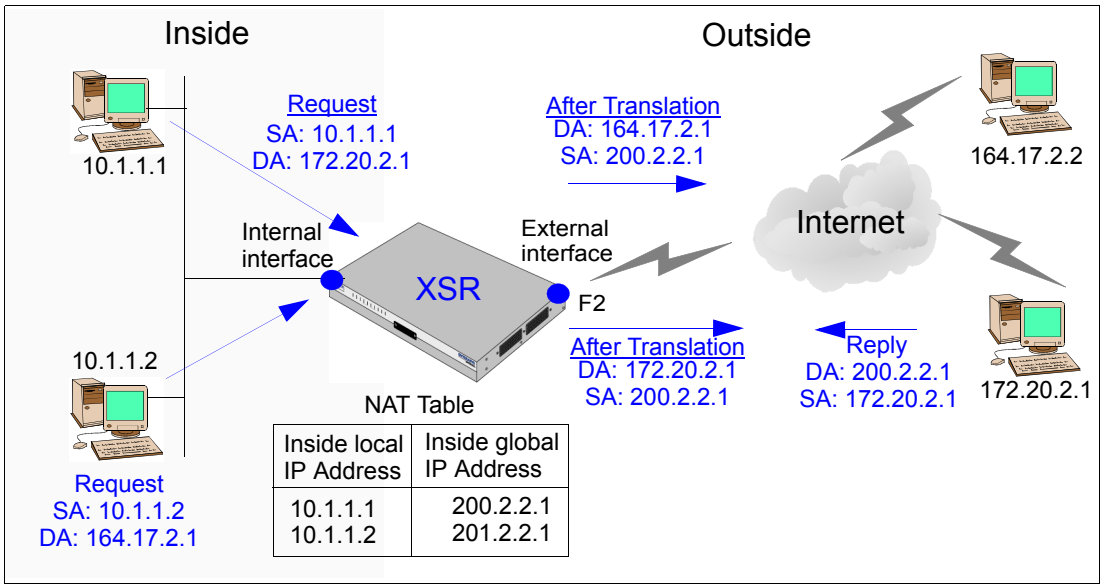
+ Adds ACL to permit IP traffic from the specified source

Multiple NAT Pools within an Interface

This scenario describes two NAT pools within interface F2. As shown in Figure 5-14, the pools are assigned to external port *F2*. One is used for packets sent to the *172.20.2.0* network and the other for the *164.17.2.0* network. Based n the ACL, outbound packets would use one of the two pools. Note that the same internal host can have mappings in both pools since it could send packets to both destinations. Packets that do not match either ACL will be sent un-NATted.

Optionally, NAPT permits packets not matching either of the pool ACLs to pass through NAPT.

Figure 5-14 Multiple NAT Pools within Interface



Multiple NAT pooling procedes as follows:

1. The user at *10.1.1.1* opens a connection to host *172.20.2.1*.

2. The first packet the XSR receives from *10.1.1.1* is checked against its ACLs. ACL *101* matches and pool *NatPool* is used. A check is made for existing mapping and if found is used otherwise a new one is created. The global address is *200.2.2.1*.
3. Packet are marked as originating from *200.2.2.1* to *172.20.2.1.*
4. Reply packets arrive at the XSR with the pool mapping on *NatPool* used to obtain private IP address *10.1.1.1*. Packets are then translated and passed on to the host.

Enter the following commands to configure multiple NAT pools:

```
XSR(config)#access-list 101 permit ip any 172.20.2.0 255.255.0.0
```
+ Configures the ACL for the destination on the 172.20.2.0 network

```
XSR(config)#access-list 102 permit ip any 164.17.2.0 255.255.0.0
```
+ Configures the ACL for the destination on the 164.17.2.0 network

```
XSR(config)#ip local pool NatPool 200.2.2.0/24
XSR(ip-local-pool)#ip local pool NatPool1 201.2.2.0/24
XSR(ip-local-pool)#exit
```
+ Create two IP local pools at the specified inside global IP addresses

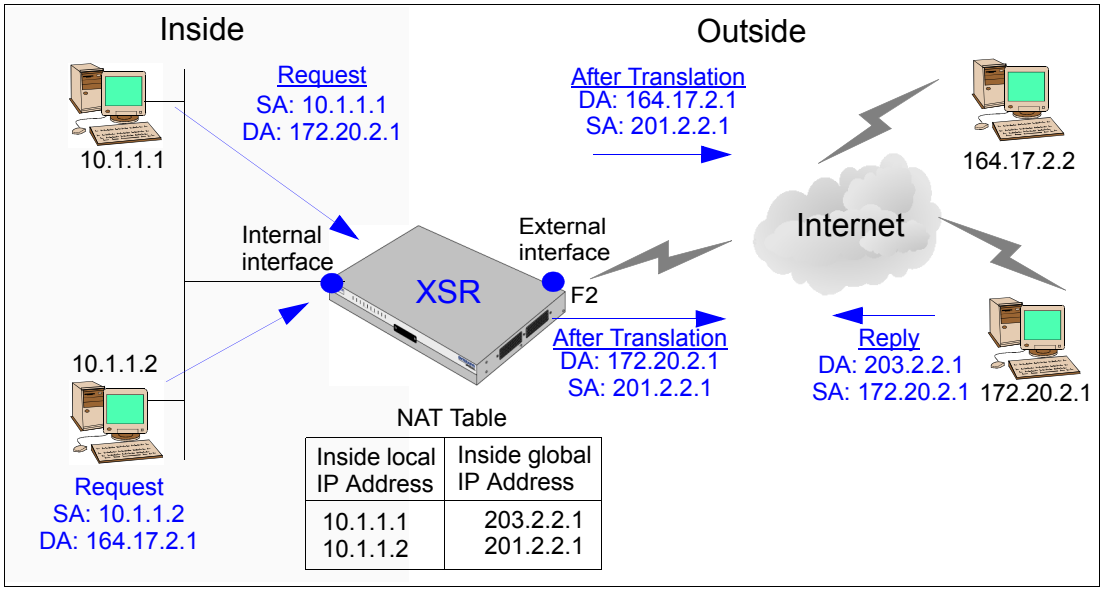
```
XSR(config)#ip nat pool NatPool
XSR(config)#ip nat pool NatPool1
```
+ Assigns the above pools to NAT

```
XSR(config)#interface F2
XSR(config-if<F2>)#ip nat source list 101 pool NatPool
XSR(config-if<F2>)#ip nat source list 102 pool NatPool1
```
+ The above optional NAPT commands use ACL 101 for the 200.2.2.0 network and ACL 102 for the 201.2.2.0 network

Static NAT within an Interface

This scenario extends the example for multiple NAT instances per interface illustrating the interaction between different NAT forms under the interface.

Figure 5-15 Static NAT within Interface



As shown in Figure 5-15, packets from the PC at *10.1.1.1* are statically NATted to the PC at *203.2.2.1* but through *neither* of the pools. This occurs because static NAT takes precedence over other NAT forms. Also, this static NAT would be used only when packets from PC *10.1.1.1* exit the *F2* interface. On any other interface the translation would not occur, unless the same mapping is configured. Static NAT within an interface procedes as follows:

1. The user at *10.1.1.1* opens a connection to host *172.20.2.1*.
2. When the XSR receives the first packet from *10.1.1.1*, the static NAT table for the interface is checked and a mapping found. That mapping is used to translate the source IP address to *203.2.2.1*.
3. The packet goes out as being transmitted from *203.2.2.1* to destination *172.20.2.1*.
4. When a reply packet is received by the XSR, static mappings are again checked resulting in the translation of the destination IP address from *203.2.2.1* to *10.1.1.1*.

Enter the following commands to configure static NAT at interface *F2*:

```
XSR(config)#access-list 101 permit ip any 172.20.0.0 0.0.255.255
```

+ Configures the ACL for the destination on the 172.20.0.0 network

```
XSR(config)#access-list 102 permit ip any 164.17.0.0 0.0.255.255
```

+ Configures the ACL for the destination on the 164.17.0.0 network

```
XSR(config)#ip local pool NatPool 200.2.2.0/24
XSR(ip-local-pool)#exit
XSR(config)#ip local pool NatPool1 201.2.2.0/24
XSR(ip-local-pool)#exit
```

+ Create two IP local pools with the specified inside global IP addresses

```
XSR(config)#ip nat pool NatPool
XSR(config)#ip nat pool NatPool1
```

+ Assigns the above pools to NAT

```
XSR(config)#interface F2
XSR(config-if<F2>)#ip nat source list 101 pool NatPool
XSR(config-if<F2>)#ip nat source list 102 pool NatPool1
```

+ The above optional NAPT commands use ACL 101 for the 200.2.2.0 network and ACL 102 for the 201.2.2.0 network

```
XSR(config-if<F2>)#ip nat source intf-static 10.1.1.1 203.2.2.1
```

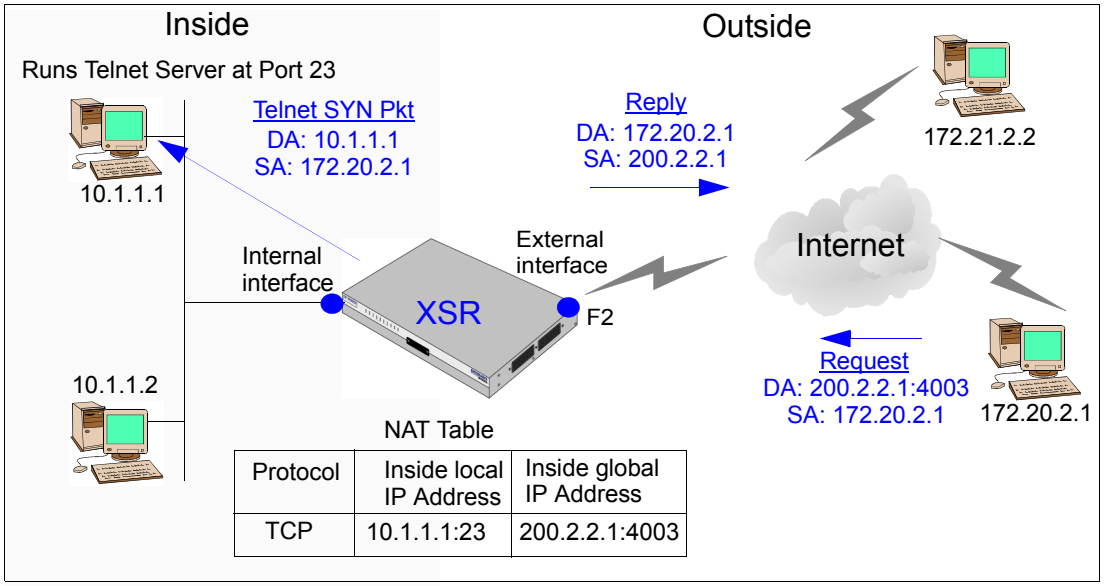
+ The above optional command statically NATs packets from 10.1.1.1 to 203.2.2.1

NAT Port Forwarding

This scenario, as shown in Figure 5-16, illustrates NAT port forwarding. The connection is initiated by the PC at *172.20.2.1* to port *4003* on *200.2.2.1*. The XSR's static NAT table is first checked for mappings. An entry is found for *200.2.2.1* (which happens to be the interface IP address, but is not required) with port *4003* mapping it to the PC at *10.1.1.1:23*. The packet is then translated and forwarded to *10.1.1.1* destined for port *23*.

The reply packet from the Telnet server once again passes to the static NAT at interface *F2* and is forwarded to *172.20.2.1* as being from *200.2.2.1:4003*.

Figure 5-16 NAT Port Forwarding



Enter the following commands to enable NAT Port Forwarding:

```
XSR(config)#interface fastethernet2
XSR(config-if<F2>)#ip address 200.2.2.1/24
XSR(config-if<F2>)#ip nat source intf-static tcp 10.1.1.1 23 200.2.2.1 4003
XSR(config-if<F2>)#ip nat source assigned overload
```

Configuring Policy Based Routing Example

The following example configures PBR to forward to a next-hop router:

```
XSR(config)#access-list 101 permit ip 10.10.10.0 0.0.0.255 192.168.5.0 0.0.0.255
```

The commands below configure GigabitEthernet interface 1 with an IP address, and enable PBR with the **`ip policy`** command:

```
XSR(config)#interface GigabitEthernet 1
XSR(config-if<G1>)#ip address 192.168.5.1 255.255.255.0
```

```
XSR(config-if<G1>)#ip policy
```

These commands create the PBR, map it to ACL 101, and set the forwarding router as 192.168.5.2:

```
XSR(config)#route-map pbr 101
XSR(config-pbr-map)#match ip address 101
XSR(config-pbr-map)#set ip next-hop 192.168.5.2
```

Configuring VRRP Example

The following example configures three VRRP groups to provide forwarding redundancy and load balancing on VRRP routers *XSRa* and *XSRb* as follows:

- Group 1: the virtual IP address is 10.10.10.10, *XSRa* is the group master with priority *120*, the advertising interval is 3 seconds, preemption is enabled with a 2-second delay, and authentication is set with the text *robo*.
- Group 5: *XSRb* is the group master with priority *200*, the virtual IP address is 10.10.10.50, the advertising interval is 30 seconds, and preemption is enabled with a 2-second delay.
- Group 100: *XSRa* is the group master with priority *85*, the advertising interval is 1 second (default), and preemption is off.
- The WAN Serial interface 2/0 is tracked by FastEthernet interface 1 on each likely master VR.

Router XSRa

```
XSRa(config)#interface fastethernet 1/0
XSRa(config-if<F1>)#ip address 10.10.10.2 255.255.255.0
XSRa(config-if<F1>)#vrrp 1 priority 150
XSRa(config-if<F1>)#vrrp 1 preempt delay 2
XSRa(config-if<F1>)#vrrp 1 track serial 2/0
XSRa(config-if<F1>)#vrrp 1 authentication robo
XSRa(config-if<F1>)#vrrp 1 adver-int 3
XSRa(config-if<F1>)#vrrp 1 ip 10.10.10.10
XSRa(config-if<F1>)#vrrp 5 priority 100
XSRa(config-if<F1>)#vrrp 5 adver-int 30
XSRa(config-if<F1>)#vrrp 5 ip 10.10.10.50
XSRa(config-if<F1>)#vrrp 5 preempt delay 2
XSRa(config-if<F1>)#vrrp 100 ip 10.10.10.100
XSRa(config-if<F1>)#vrrp 100 priority 85
XSRa(config-if<F1>)#no vrrp 100 preempt
XSRa(config-if<F1>)#vrrp 100 track serial 2/0
XSRa(config-if<F1>)#no shutdown
```

Router XSRb

```
XSRb(config)#interface fastethernet 1/0
XSRb(config-if<F1>)#ip address 10.10.10.1 255.255.255.0
XSRb(config-if<F1>)#vrrp 1 priority 100
XSRb(config-if<F1>)#vrrp 1 preempt delay 2
XSRb(config-if<F1>)#vrrp 1 authentication robo
XSRb(config-if<F1>)#vrrp 1 adver-int 3
XSRb(config-if<F1>)#vrrp 1 ip 10.10.10.10
```

```
XSRb(config-if<F1>)#vrrp 5 priority 200
XSRb(config-if<F1>)#vrrp 5 adver-int 30
XSRb(config-if<F1>)#vrrp 5 ip 10.10.10.50
XSRb(config-if<F1>)#vrrp 5 preempt delay 2
XSRb(config-if<F1>)#vrrp 5 track serial 2/0
XSRb(config-if<F1>)#vrrp 100 ip 10.10.10.100
XSRb(config-if<F1>)#vrrp 100 priority 65
XSRb(config-if<F1>)#no vrrp 100 preempt
XSRb(config-if<F1>)#no shutdown
```

Configuring VLAN Examples

The following example configures a VLAN interface on FastEthernet sub-interfaces 2.1 and 2.2:

```
XSR(config)#interface FastEthernet 2.1
XSR(config-if<F1.2>)#vlan 1200
XSR(config-if<F1.2>)#ip address 1.2.3.4 255.255.255.0
XSR(config-if<F1.2>)#no shutdown
XSR(config-if<F1.2>)#exit
XSR(config)#interface FastEthernet 2.2
XSR(config-if<F2.2>)#vlan 1300
XSR(config-if<F2.2>)#ip address 2.2.3.4 255.255.255.0
XSR(config-if<F2.2>)#no shutdown
```

The following example configures a VLAN interface for PPPoE:

```
XSR(config)#interface FastEthernet 2.4
XSR(config-if<F2.4>)#encapsulate ppp
XSR(config-if<F2.4>)#vlan 1400
XSR(config-if<F2.4>)#ip address negotiated
XSR(config-if<F2.4>)#ip mtu 1492
XSR(config-if<F2.4>)#no shutdown
```

For a QoS with VLAN example, refer to "QoS with VLAN" on page 14.

6

Configuring the Border Gateway Protocol

Features

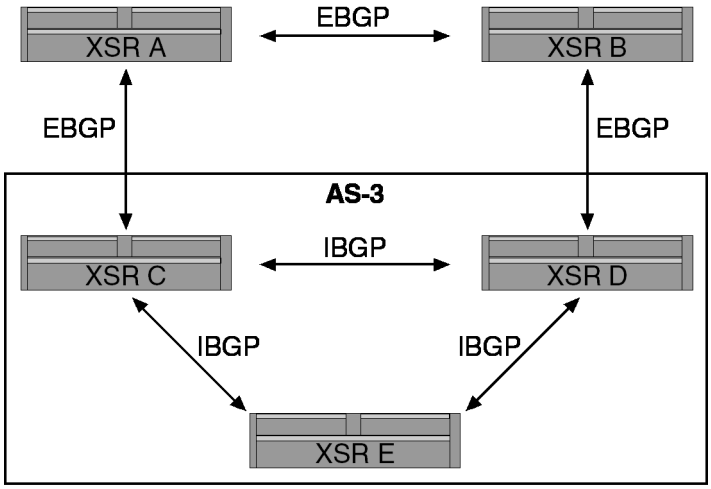
The XSR supports the following the Border Gateway Protocol (BGP-4) features:

- Full mandatory BGP v4 protocol support (RFC-1771)
- Support for all BGP v4 MIB tables defined in RFC-1657 including BGP SNMP traps
- Protection of BGP Sessions: TCP MD5 Signature Option (RFC-2385)
- BGP Capabilities advertisement (RFC-2842)
- BGP Route reflection (RFC-2796)
- BGP Communities (RFC-1997)
- Route Refresh (RFC-2918)
- BGP Route Flap dampening (RFC-2439)
- AS Confederations for BGP (RFC-3065)
- BGP debug capability

Overview

BGP-4 is an Exterior Gateway Protocol (EGP) typically used to swap routing data among different Autonomous Systems (AS). An AS is defined as a network or group of networks that run under a common administration and with a common set of routing policies. BGP supports two types of exchanges of routing information: exchanges between different ASs (*inter*-AS) and exchanges within a single AS (*intra*-AS). When BGP is used between different ASs, the protocol is referred to as External BGP (EBGP). If BGP is used to exchange routes within an AS, then the protocol is referred to as Interior BGP (IBGP), as shown in Figure 6-1.

Figure 6-1 Differentiating EBGP from IBGP



BGP can be categorized as a path vector routing protocol which defines a route as a pairing between a destination and the qualities of the path to that destination. The main role of a BGP-speaking node is to trade network reachability data with adjacent BGP nodes known as neighbors or peers. This reachability data includes a list of AS's that have been traversed along the way. By using this list, an AS connectivity grid can be built from which routing loops may be pruned and some policy decisions at the AS level may be enforced.

Like other protocols, BGP uses the Transmission Control Protocol (TCP) as its transport protocol. Running over a reliable transport protocol eliminates the need for BGP to use fragmentation, retransmission, acknowledgment, and sequencing BGP uses TCP port 179 to build its links.

BGP neighbors exchange full routing data when the TCP link between neighbors is first established. When routing table changes are detected, BGP routers send only changed routes to their neighbors. BGP routers do not transmit periodic routing updates, and BGP routing updates advertise only the best path to a destination network.

BGP permits policy-based routing which choose among multiple paths to a destination and control the redistribution of routing data.

BGP-4 supports Classless Inter-Domain Routing (CIDR), which dispenses with network classes, as wells as route aggregation, including the aggregation of AS paths and supernetting.

Describing BGP Messages

BGP nodes exchange four types of messages, including *Open*, *Update*, *Keepalive*, and *Notification*. They are described as follows.

Open

After two BGP nodes are connected via TCP, they exchange BGP *open* messages to build a BGP link between them. Once the connection is set up, the nodes trade BGP messages and data traffic.

Open messages consist of the BGP header as well as the following fields:

- *Version*: The current protocol version number of the message. The current BGP version number is 4.
- *Local AS number*: Autonomous System number of the sender.

- *Hold time*: Number of seconds that the sender proposes for the value of the Hold Timer. The hold time defines the interval that can elapse without the receipt of an Update or KeepAlive message before the peer is assumed to be disabled.
- *BGP identifier*: IP address of the BGP node (Router ID).
- *Parameter field length* and the *parameter* itself: Optional fields.

Update

BGP nodes send update messages to swap network reachability data between BGP peers. The nodes use this information to build a graph describing the relationships among all known ASs.

Update messages comprise the BGP header plus the following optional fields:

- *Unfeasible routes length*: Length of the field that lists the routes being withdrawn from service because they are judged no longer reachable.
- *Withdrawn routes*: IP address prefixes for the routes being withdrawn from service.
- *Total path attribute length*: Length of the field that lists the path attributes for a feasible route to a destination.
- *Path attributes*: Properties of the routes, including the path origin, the multiple exit discriminator (MED), the originating node's preference for the route, and data about aggregation, communities, confederations, and route reflection.
- *Network layer reachability information (NLRI)*: IP address prefixes of feasible routes being advertised in the update message.

Keepalive

BGP nodes exchange keepalive messages to learn whether a link or host is down or unavailable. Keepalive messages are exchanged often enough so that the hold timer does not expire. They consist only of the BGP header.

When a link is initiated, BGP negotiates the hold time with the neighbor and selects the lesser interval. The keepalive timer is then set based on the *negotiated hold* and *configured keepalive* intervals with the XSR maintaining a hold interval that is three times the keepalive.

You can reset the default keepalive interval with the **`timers bgp keep-alive`** command. If you set the variable to 0, keepalives will not be sent. Hold intervals cannot be configured.

Notification

BGP nodes send notification messages when an error condition is learned. After the message is sent, the BGP session and TCP connection between the BGP nodes are closed. Notification messages consist of the BGP header, the error code and subcode, and data that describes the error.

Defining BGP Path Attributes

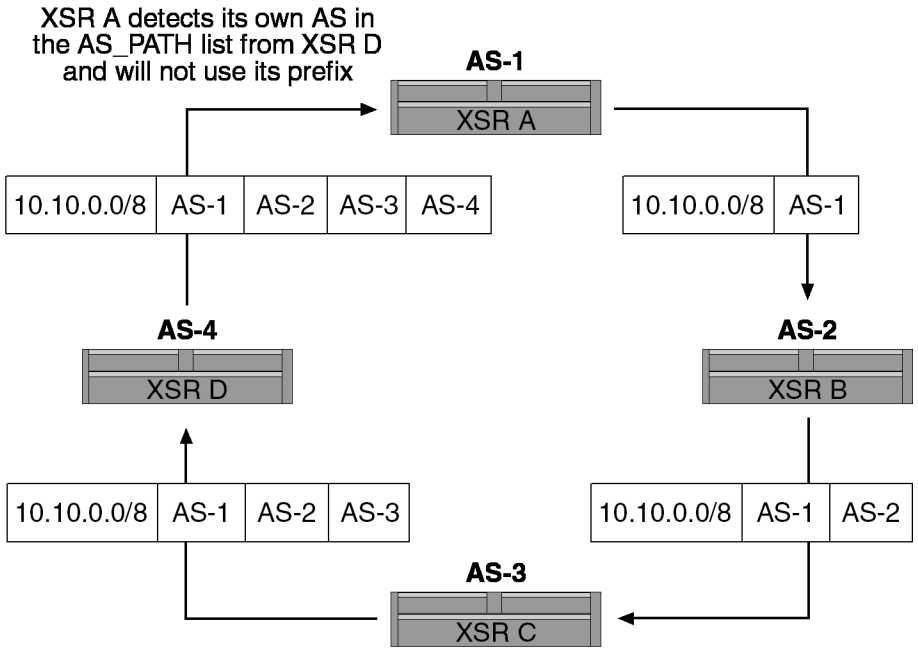
BGP path attributes are defined as a set of parameters describing the traits of a path to a destination IP prefix. They are used extensively in the route selection process to select the best of multiple routes, and to build routing policies by matching and setting attributes.

AS Path

The AS_PATH attribute, as shown in Figure 6-2, is the sequence of AS numbers a route has traversed to reach a destination. The AS that originates the route adds its own AS number when sending the route to its EBGP peers. Subsequently, each AS that receives the route and passes it on to other BGP peers will prepend its own AS number to the list. When the route is passed to a BGP speaker within the same AS (IBGP peer), the AS_PATH data remains intact. The final list represents all the AS numbers that a route has traversed with the AS number of the AS that originated the route all the way at the end of the list.

BGP uses the AS_PATH attribute in its routing updates to ensure a loop-free topology on the Internet. If the route is advertised to the AS that originated it, that AS will see itself as part of the AS_PATH attribute list and will not accept the route. The attribute can be manipulated with the **`ip as-path access-list`** command. The **`match as-path`** command associates a route map's as-path with a particular ACL. The **`set as-path`** command increases the length of the AS-path attribute for updates that meet the match conditions specified within a route map.

Figure 6-2 AS Path List



AS_PATH data is one of the attributes BGP considers to determine the best route to a destination. When comparing two or more different routes, if all other attributes are identical, a shorter path is always preferred. In case of a tie in AS_PATH length, other attributes are used in the decision.

Origin

The ORIGIN attribute indicates the origin of the routing update as follows:

- *IGP*: The prefix is *internal* to the originating AS.
- *EGP*: The prefix was *learned* via some EGP.
- *INCOMPLETE*: The prefix was learned by some other means, usually via redistribution or aggregation.

BGP considers the ORIGIN attribute in its decision-making process to set a preference ranking among multiple routes. Namely, BGP prefers the path with the lowest origin type, where IGP is lower than EGP, and EGP is lower than INCOMPLETE.

The attribute is configured with the **`set origin`** command.

Next Hop

The NEXT_HOP attribute is the next IP address used to reach a destination. Usually, BGP chooses the next hop automatically but in networks where BGP neighbors may not have direct access to all other neighbors on the same subnet, BGP's automatic next hop selection can result in broken routing.

Use the **`neighbor next-hop-self`** command to disable automatic next-hop selection. It forces the BGP speaker to report itself as the next hop for an advertised route it advertised to a neighbor. Typically, this command prevents third-party next hops from being used on NBMA media such as Frame Relay.

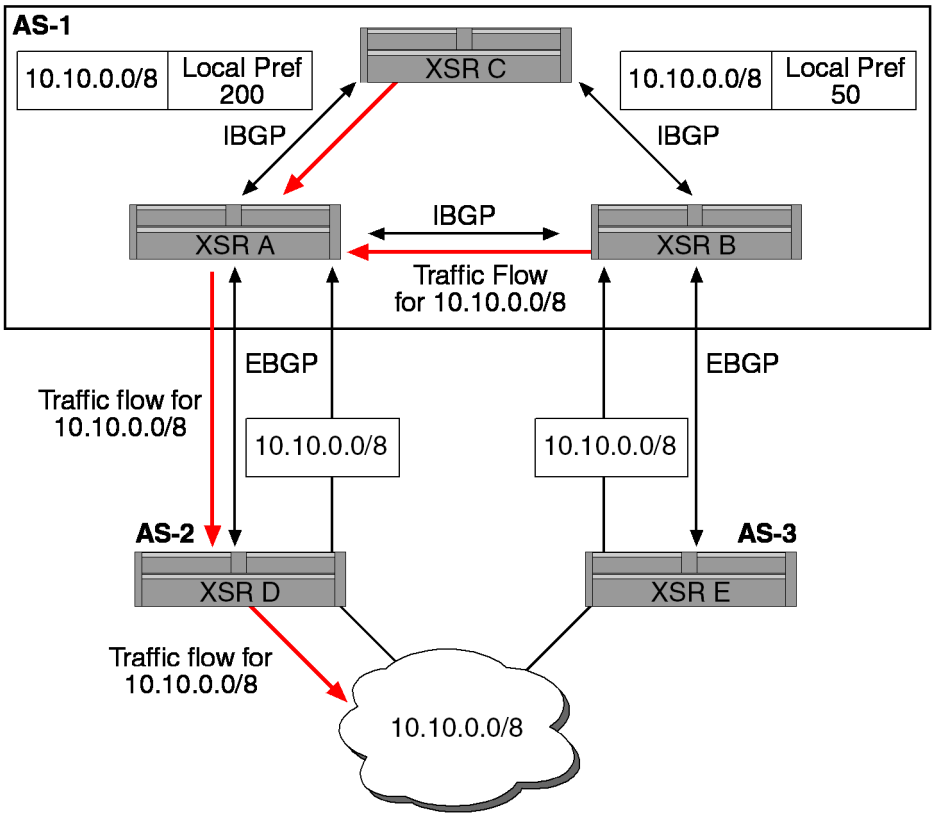
Next-hop is set on an outbound route map using the **`set ip next-hop`** command or the **`neighbor next-hop-self`** command depending on the granularity required.

Local Preference

The LOCAL_PREF attribute informs other peers within an AS of the originator's degree of preference for a particular route out of an AS (it influences egress traffic). The degree of preference given to a route is compared with that of other routes for the same destination with higher LOCAL_PREF values preferred, as shown in Figure 6-3. LOCAL_PREF is local to the AS, is traded between IBGP peers only; it is not advertised to EBGP peers.

Refer to "BGP Community with Route Maps Examples" on page 6-26 for a configuration example.

Figure 6-3 Local Preference Applied to Direct Egress Traffic from AS.

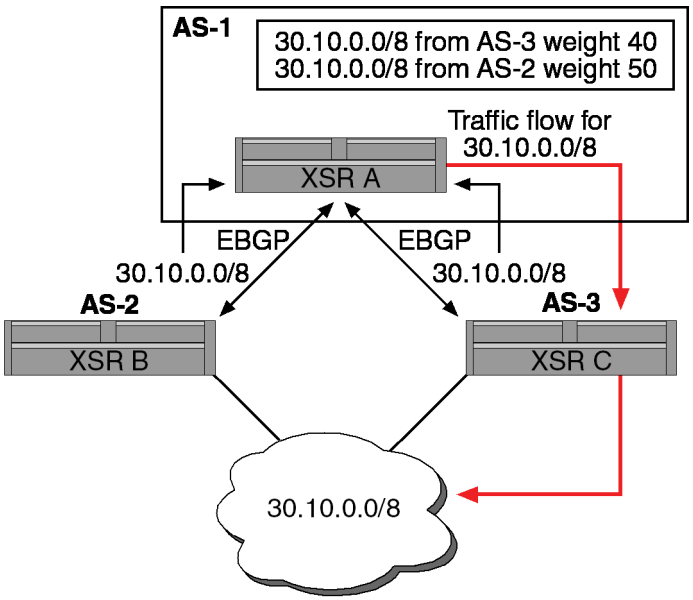


Weight

Weight, as shown in Figure 6-4, and LOCAL_PREF attributes are similar except that weight is not exchanged between routers. It is significant only locally. Higher preference is accorded the route with a higher weight. Weight can be used to influence routes coming from different providers to the same router (one router with multiple connections to two or more providers).

The attribute is configured with the **`set weight`** command.

Figure 6-4 Weight Applied to Differentiate Between Routes from Multiple Sources



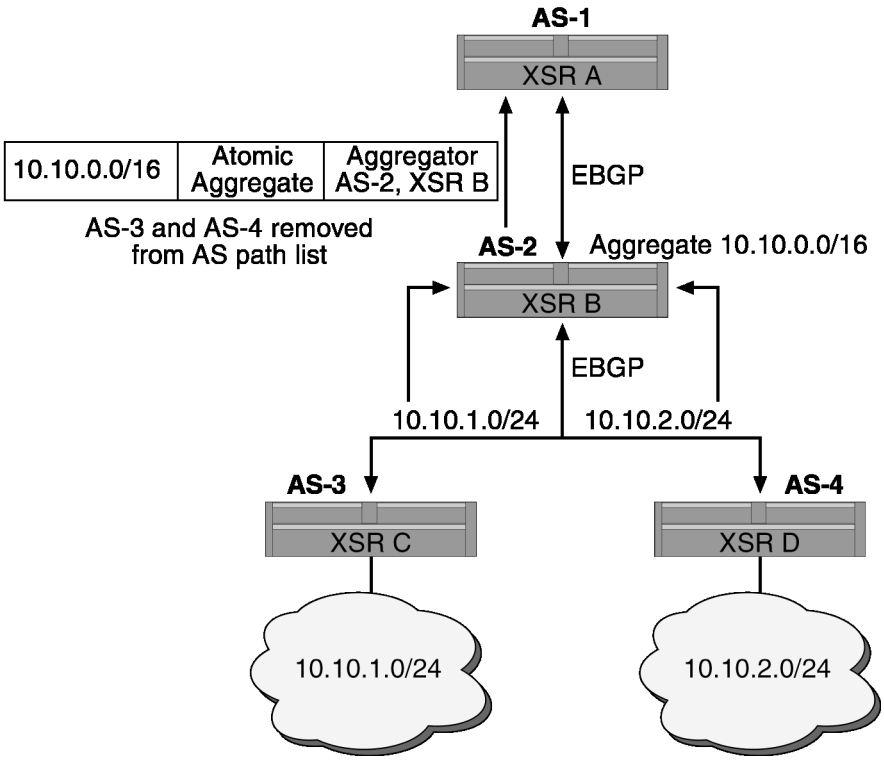
Atomic Aggregate

The XSR automatically sets the ATOMIC_AGGREGATE attribute if the aggregate that a BGP speaker distributes is selected as less specific than a route included with it. A route with this attribute cannot be de-aggregated (made more specific). Forwarding along such a route does not ensure that IP packets will actually cross only AS's listed in the route's AS_PATH attribute.

Aggregator

The AGGREGATOR attribute, as shown in Figure 6-5, is added by the BGP speaker that formed the aggregate route. It includes the AS and router ID of the BGP speaker that originated the aggregate prefix. It is commonly used for debugging purposes.

Figure 6-5 Aggregate and Aggregator Attribute



Multi-Exit Discriminator

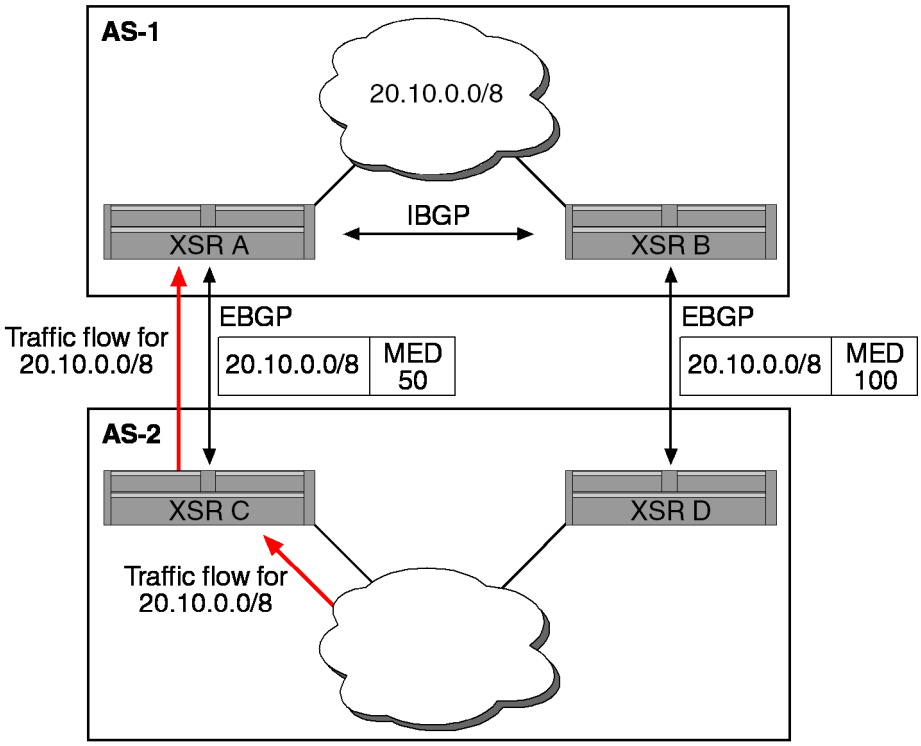
The MULTI_EXIT_DISC (MED) attribute, as shown in Figure 6-6, is applied to external (inter-AS) links to discriminate among multiple exit or entry points into the same neighboring AS (influencing ingress traffic). The MED informs external neighbors about the preferred path into an AS that has multiple entry points with the rule that a lower MED is the preferred path over a higher MED. Comparing MEDs is performed only among paths from the same AS by default but you can compare MEDs from different AS's with the **`bgp always-compare-med`** command.

Unlike the local preference attribute, the MED is exchanged between AS's, but a MED that enters an AS does not leave the AS. When an update enters the AS with a certain MED, that value is used for decision-making within the AS.

When BGP relays the routing update to another AS, the MED is reset to zero (unless the outgoing MED is set to a specific value). Unless otherwise specified, the XSR compares MEDs for paths from external neighbors occupying the same AS. MEDs from different AS's typically are not comparable because the MED associated with a route usually indicates the AS internal topology.

The **`set metric`** command specifies the MED of redistributed routes that match a specified route map; be aware that routes even lacking a MED value are set as well. You can penalize a path without a MED as the least desirable path available using the **`bgp bestpath missing-as-worst`** command. This path is assigned a value of infinity.

Figure 6-6 MED Applied to Direct Ingress Traffic Flow to an AS



Community

A BGP community, as shown in Figure 6-7, is defined as a group of destinations that share some common property and is not limited to one network or AS. Communities simplify routing policies by identifying routes based on a logical property rather than an IP prefix or AS number. A BGP speaker can then use this attribute along with others to control which routes to accept, prefer, and relay to other BGP neighbors.

The XSR supports the following *predefined* communities based on the BGP COMMUNITIES attribute:

- *aa:nn* - Advertise a particular AS and community number.
- *internet* - Specifies the entire Internet community.
- *no-export* - Do not advertise this route to an EBGP peer.
- *no-advertise* - Do not advertise this route to any peer (internal or external).

Based on one of the following values, the XSR supports BGP routing policies:

- IP address
- AS_PATH
- COMMUNITIES

Based on a shared common attribute, a community comprises multiple destinations. But, each destination can also belong to multiple communities. While you can specify which communities comprise a destination, all destinations belong to the default *Internet* community.

By creating a community list, you control which routing data to accept, prefer, or distribute to other neighbors. A BGP speaker can set, append, or modify the community of a route when you

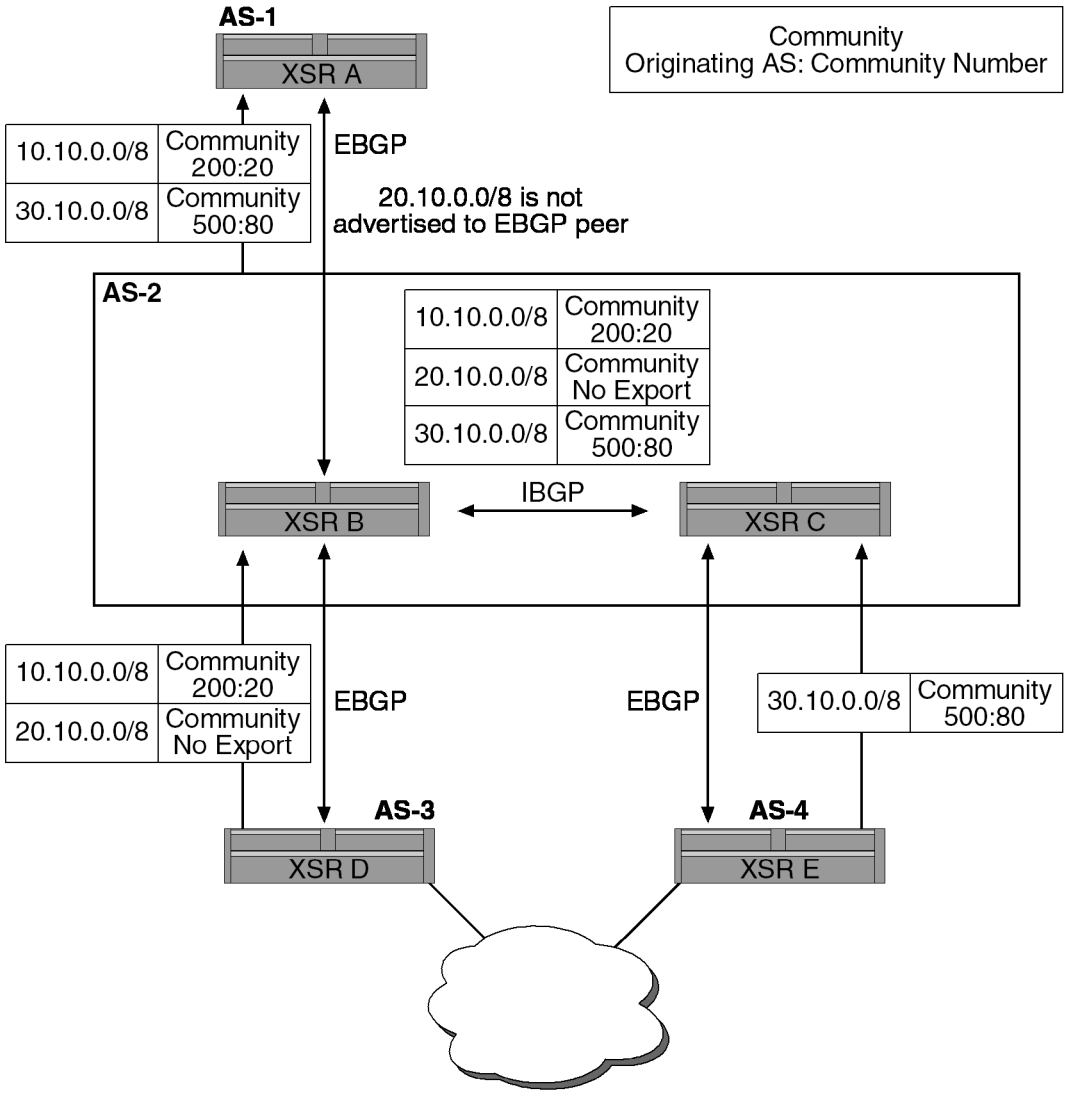
learn, advertise, or redistribute routes. When routes are aggregated, the resulting aggregate has a COMMUNITIES attribute that contains all communities from all the initial routes.

Community lists form groups of communities for use in a route map's match clause. Similar to ACLs, you can create a series of community lists where statements are checked until a match is found and when one statement is satisfied, the test is finished with the **`ip community-list community-list-number {permit | deny} community-number`** command.

To configure the COMMUNITIES attribute and match clauses based on communities, refer to the **`match community-list`** and **`set community`** command descriptions in "BGP Community with Route Maps Examples" on page 6-26 and the *XSR CLI Reference Guide.*

Although a COMMUNITIES attribute is not sent to a neighbor by *default*, you can specify the attribute be sent to the neighbor at an IP address with the **`neighbor {ip-address | peer-group-name} send-community`** command.

Figure 6-7 Application of Community Attribute

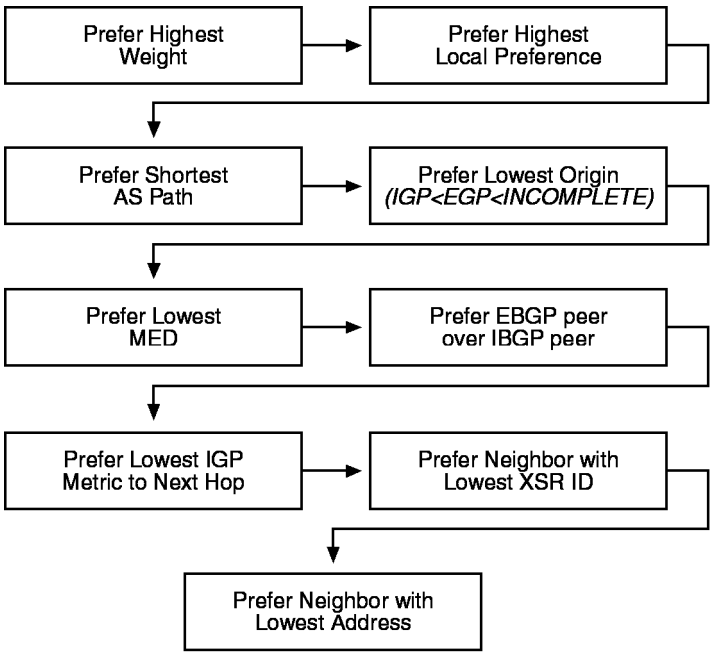


BGP Path Selection Process

BGP routers usually consider multiple paths to a destination. The BGP best path selection process decides the optimal path to install in the IP routing table and use for forwarding traffic.

Only routes that are synchronized, are free of AS loops and have a valid next-hop are considered in the selection process, as illustrated in Figure 6-8.

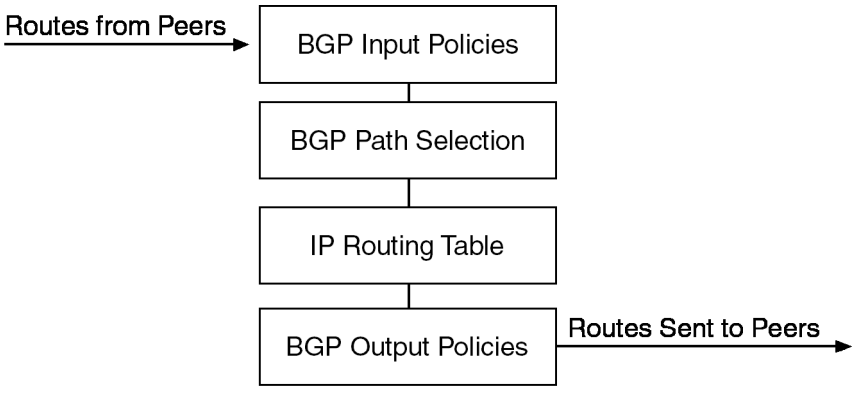
Figure 6-8 BGP Path Selection Algorithm



BGP Routing Policy

The XSR employs *Access Control Lists* (ACLs), *filter lists*, *community lists*, *route maps*, *regular expressions*, and *peer groups* to implement BGP routing policy, (refer to Figure 6-9. These features are described in the following pages.

Figure 6-9 BGP Routing Policy Process



Access Control Lists

Access Control Lists (ACLs) are filters which permit or deny access to one or more IP addresses. ACLs generally apply to both route updates and packet filtering but with BGP, route update filtering is emphasized. *Prefix-based* ACLs control access by specifying which IP addresses are permitted or denied via the network prefix number.

The XSR filters BGP advertisements as follows:

- with AS-path filters using the **`ip as-path access-list`** and **`neighbor filter-list`** commands.
- with ACLs using the **`neighbor distribute-list {access-list} {in | out}`** command.

Routing data the XSR learns or advertises can be filtered by controlling BGP routing updates through ACLs applied to the updates.

Note: Distribute-list filters are applied to network numbers, not AS paths.

Filter Lists

As-path filter lists control access by specifying which AS paths to permit or deny. They are configured with the **`ip as-path access-list <ACL#> {permit | deny} as-regular-expression`** command. To further filter BGP paths by neighbor, use the **`neighbor filter-list access-list-number {in | out}`** command.

Community Lists

Community lists control access by specifying which communities are permitted or denied. Community-based ACLs are configured with the **`ip community-list`** command.

Route Maps

Route maps act with BGP to control and modify routing data and define the conditions by which routes are redistributed between routing domains. Route maps are similar to ACLs in that they both have rules for matching packets and when matches are found, act to permit or deny the packet. Route maps are flexible and powerful in that they not only match, permit and deny, they also change route attributes.

The XSR performs a match on AS-path, community, and network numbers for both incoming and outgoing updates with the **`match as-path`**, **`match community-list`**, and **`match ip address`** commands, respectively. You add a route map to in/outbound routes with the **`neighbor {ip-address | peer-group-name} route-map <route-map#> {in | out}`** command.

Refer to "BGP Community with Route Maps Examples" on page 6-26 for route-map examples.

Each route map includes sets of instructions that include:

- A permit or deny statement
- A sequence number
- An optional match clause
- An optional set clause

Route maps used with BGP can perform the following:

- Apply a weight to a specific route with **`set weight`**

- Set community attributes for a specific route with **`set community`**
- Set the origin for a specific route with **`set origin`**
- Set the MED of a specific route with **`set metric`**
- Set the local preference for a specific route with **`set local-preference`**
- Set the AS-Path list for a specific route with **`set as-path`**
- Set the dampening parameters for a specific route with **`set dampening`**
- Set the next hop IP address for a specific route with **`set ip next-hop`**

Regular Expressions

Regular expressions commonly notate text string patterns. They specify rules for a set of strings you may want to match in a search. With BGP, regular expressions search AS paths to match a particular pattern and are especially useful in building complex policies. Regular expressions are evaluated from left to right in sequence with binary logic. A number denotes a literal numeral and AS number. Special characters denote position or operation within a string.

Regular Expression Characters

- 0 through 9 numerals are *literals*, used in any combination to represent an AS number
- '^' marks the beginning of a path
- '$' marks the end of a path
- '{' marks the beginning of an AS_SET
- '}' marks the end of an AS_SET
- '(' marks the start of an AS_CONFED_SET or AS_CONFED_SEQ
- ')' marks the end of an AS_CONFED_SET or AS_CONFED_SEQ

To match AS numbers in an AS path, use any of the following expressions:

- '.' Matches any valid AS number
- '.*' matches 0 or more sequence or AS numbers
- '.+' matches 1 or more of the sequence of AS numbers
- '_' (underscore) matches 0 or 1 instance of any punctuation character
- [ ] specifies a set of AS numbers or punctuation, for example, "[1234 45 6789]" or "[{( ]", all members of a set must be the same type, i.e. either AS numbers or punctuation
- '-' is used within brackets to specify a range of AS numbers, for example "[23 - 45]"
- '^' when used as the first item within brackets specifies any AS number except the set specified; for example, to specify any AS number other than 11 or 13 use "[^11 13]"

Regular Expression Examples

The following displays some common examples for matching AS paths using regular expressions with the **`show ip bgp regexp`** command.

- Display all routes with a single AS number in the AS path:
  - **`show ip bgp "."`**

- Display all routes with any AS path:
  - **show ip bgp "\.*"**
- Display all routes having at least two AS numbers in the AS path:
  - **show ip bgp "\. \.+"**
- Display all routes that traversed AS number 600:
  - **show ip bgp "\.* 600 \.*"**
- Display all routes with beginning with AS number 300 and ending with AS number 800 in the AS path:
  - **show ip bgp "\^300 \.* 800$"**

Peer Groups

A BGP peer group is a set of BGP neighbors sharing update policies. Rather than define similar policies for each individual neighbor, you can define a peer group and assign policies to the peer group itself. If you modify options for the peer group, all members of the peer group inherit the changes. You can also configure individual members to override those options that do not effect outbound updates.

Peer-groups are comprised of either IBGP or EBGP members. *IBGP* group members must be in the same AS as the peer-group, which itself must be in the same AS as the router. On the other hand, when you create an *EBGP* peer-group, an AS number is not associated with the peer-group and all peer-group members must belong to an AS *other* than the AS set for the router.

Do not mix IBGP and EBGP members in the same peer-group. Members of an EBGP group can be from different ASs. A peer can belong to a single peer-group only.

A BGP peer group is configured by:

- Creating the peer group
- Assigning Options
- Adding neighbors

A BGP peer or peer group can be disabled without deleting all settings with the **neighbor shutdown** command.

Creating a Peer Group

Create a BGP peer group and add a neighbor to it with the **neighbor peer-group** command.

Assigning Peer Group Options

A peer group is set with **neighbor** commands. Peer group members inherit all group options as well as subsequent changes by default. They can also be configured to override those options not pertinent to outbound updates.

Members of a peer group always inherit these attributes: **remote-as** (if configured), **update-source**, **neighbor filter-list**, **advertisement-interval**, and **next-hop-self**.

You can set options for an particular neighbor by using any of the following commands with an *IP address*. If you want to configure options for a peer group, configure any of the commands employing the *peer group name*.

- Configure a BGP neighbor: **neighbor remote-as number**

- Permit a local BGP speaker to send the default route 0.0.0.0 to a neighbor as the default route: **`neighbor default-originate`**
- Configure the COMMUNITIES attribute to be sent to the neighbor at this IP address: **`neighbor send-community`**
- Permit interior BGP sessions to use any working interface for TCP links: **`neighbor update-source interface`**
- Permit BGP sessions, even when the neighbor is not on a directly connected segment: **`neighbor ebgp multihop`**
- Specify the minimum interval between BGP routing update transmissions: **`neighbor advertisement-interval seconds`**
- Configure MD5 authentication on a TCP link to a BGP peer: **`neighbor password <value>`**. For an example, refer to "TCP MD5 Authentication for BGP Example" on page 6-25.
- Specify BGP routing updates to/from neighbors, as detailed in an ACL: **`neighbor distribute-list {ACL#}{in | out}`**
- Set up a BGP filter: **`neighbor filter-list ACL# {in | out}`**
- Disable next-hop processing on BGP updates to a neighbor: **`neighbor next-hop-self`**
- Assign a route map to in or outbound routes: **`neighbor route-map map-# {in | out}`**
- Set the XSR to begin storing received updates: **`neighbor soft-reconfiguration inbound`**
- Disable a BGP neighbor or peer group: **`neighbor shutdown`**. Conversely, you can enable a previously existing neighbor or neighbor peer group that was disabled with **`no neighbor shutdown`**

For configuration examples, refer to "Configuring BGP Peer Groups" on page 6-25.

Initial BGP Configuration

Begin BGP configuration by enabling BGP routing:

- Enable a BGP Routing process and acquire Router Configuration mode: **router bgp <AS #>**
- Mark a "local" network in this AS, adding it as an entry in the BGP Routing table: **network <IP address> mask <subnet>**

Adding BGP Neighbors

Adding neighbors to a BGP network is fundamental to building a BGP environment. You can add *internal* neighbors (those inside an AS) or *external* neighbors (those in other AS's). Usually, external neighbors are next to each other and share a subnet while internal neighbors may be situated anywhere in the same AS. The process on the XSR is as follows:

- Add a BGP network: **network <IP address> mask <mask>**
- Add a BGP neighbor: **neighbor <IP address> remote-as <as #>**

For an example, refer to "Configuring BGP Neighbors" on page 6-23.

Resetting BGP Connections

If you alter any BGP configuration values that you have defined for BGP neighbors, you must reset that BGP connections for the configuration change to take effect.

- Reset one or more BGP connections: **clear ip bgp address**

Synchronization

When an AS provides transit service to other ASs and if there are non-BGP routers in the AS, transit traffic might be dropped if the intermediate non-BGP routers have not learned routes for that traffic via an IGP. BGP synchronization, which is enabled on the XSR by default, stipulates that a BGP router should not advertise to external neighbors destinations learned from IBGP neighbors unless those destinations are also known via an IGP. If a router is so informed, it assumes that the route has already been propagated inside the AS, and internal reachability is guaranteed. Synchronization can be disabled with the **`no synchronization`** command if either of the following conditions pertain:

- Your AS does not pass traffic from one AS to another AS.
- All the transit routers in your AS run BGP.

Address Aggregation

BGP routing tables are likely to include thousands of entries so maintaining and updating a large table can prove processor intensive. BGP counters this problem by enabling specific networks to be consolidated into aggregate routes, thus reducing the size of the BGP routing table.

They can be configured either by redistributing an aggregate route into BGP or by using the conditional aggregation options described below. The XSR adds an aggregate address to the BGP table if there is at least one more specific entry there. The **`aggregate-address`** command adds an aggregate address to the routing table with the following options:

- Adds an aggregate entry to the BGP routing table: **`<address><mask>`**
- Generates AS set path data: **`[as-set]`**
- Advertises summary addresses only: **`[summary-only]`**
- Creates an aggregate reflecting values configured in the route map: **`[advertise-map]`**
- Creates an aggregate with route map parameters: **`[attribute-map]`**

Route Flap Dampening

Routes *flap* or oscillate when a route is advertised and then withdrawn, or a route is withdrawn and re-advertised in rapid succession. EBGP flapping causes global churn in the routing table, because as the flap ripples across the Internet each router must process the routing data change. IBGP flapping engenders irregular traffic flow and reachability problems within the local AS, and can affect EBGP stability if IBGP routes are advertised to EBGP peers. On the XSR, rapid flapping can cost significant CPU cycles spent on processing the routing updates. From the network perspective, route flapping usually indicates a problem, such as a circuit going up and down, or fatal recurring errors between BGP peers.

Route flap dampening is a reactive measure available to prevent route flaps from propagating across an internetwork by selectively suppressing route advertisement. Based on the premise that past can suggest future behavior, dampening penalizes malfunctioning routes and advertises stable routes with minimal delay. This does not preclude the likelihood of some route flapping though, since updates reflect normally occurring changes on the Internet. So, reasonable routing changes should not be penalized; that is, one flap within a few minutes does not necessarily indicate a problem, but five flaps within a few minutes probably does.

When you enable this functionality with the **`bgp dampening`** command, the XSR collects statistics about the prefix announcements and withdrawals. If a threshold of the number of pairs of withdrawals/announcements (flaps) is exceeded in a given period (the cutoff threshold), the

prefix is suppressed for a calculated period (a penalty) which is further incremented with every subsequent flap. The penalty is then decremented by a half-life value until the penalty is below a reuse threshold. So, if stable for a certain period, the hold-down is released from the prefix and the route is reused and re-advertised. You can reset dampening defaults with the **`bgp dampening [half-life | reuse | suppress | suppress-max][route-map route-map-#]`** command.

Dampening should only be used for EBGP peering at network boundaries, so that flapping can be suppressed as close to the unstable source as possible.

Recommendations for Route Flap Dampening

We recommend you configure the following dampening values with harsher treatment for /24 and longer prefixes:

- Do not start dampening before the fourth straight flap: set the *suppress* value to 3000
- Figure prefixes of /24 and longer as follows: maximum = minimum outage of 60 minutes
- Calculate prefixes /22 and /23 as follows: maximum outage of 45 minutes but potential for less because of half-life value - minimum of 30 minutes outage
- Set all other prefixes as follows: maximum outage - 30 minutes, minimum outage - 10 minutes

If a specific dampening implementation does not allow configuration of prefix-dependent values, use the softest set as follows:

- Do not start dampening before the fourth flap in a row with a maximum outage of 30 minutes, and minimum outage of 10 minutes

After dampening a route, you can display related data, including the interval before it will be unsuppressed with the **`show ip bgp dampened-paths`** command.

Capability Advertisement

BGP4 requires that when an OPEN message is received with one or more unrecognized optional parameters, BGP peering terminate. To address this issue, *capability advertisement* allows the graceful introduction of new capabilities without requiring that peering be terminated. This is achieved through a new optional parameter in the OPEN message - *capabilities* - which lists the capabilities supported by the speaker.

Route Refresh

When an inbound routing policy for a peer changes, all prefixes from that peer must be made available and then re-examined against that new policy. This can be performed by:

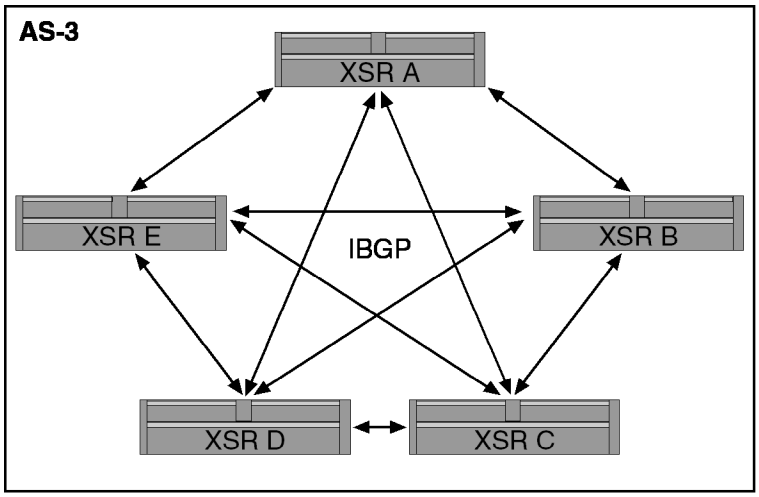
- Resetting the BGP session with the neighbor. This invalidates the cache, adversely affecting network operation.
- Performing *soft reconfiguration* which stores an unmodified copy of all routes from a particular peer at all times by using the **`neighbor soft-reconfiguration inbound`** command. This reconfiguration activates policies without actually clearing the BGP policy but imposes a higher memory cost.

The XSR's route refresh capability offers an alternative by introducing the dynamic exchange of a route refresh request message between BGP peers. Receiving this request from a peer causes the subsequent re-advertisement of all outbound prefixes that satisfy outbound policy constraints to that peer.

Scaling BGP

BGP requires that all BGP speakers with a single AS (IBGP) be *fully meshed*, as shown in Figure 6-10. The result is that for any BGP speakers within an AS, the number of unique BGP sessions required is determined by the following formula: *n x (n-1)/2*. Be aware that this fully meshed requirement does not scale when a large number of IBGP speakers occupy the AS.

Figure 6-10 Fully Meshed BGP



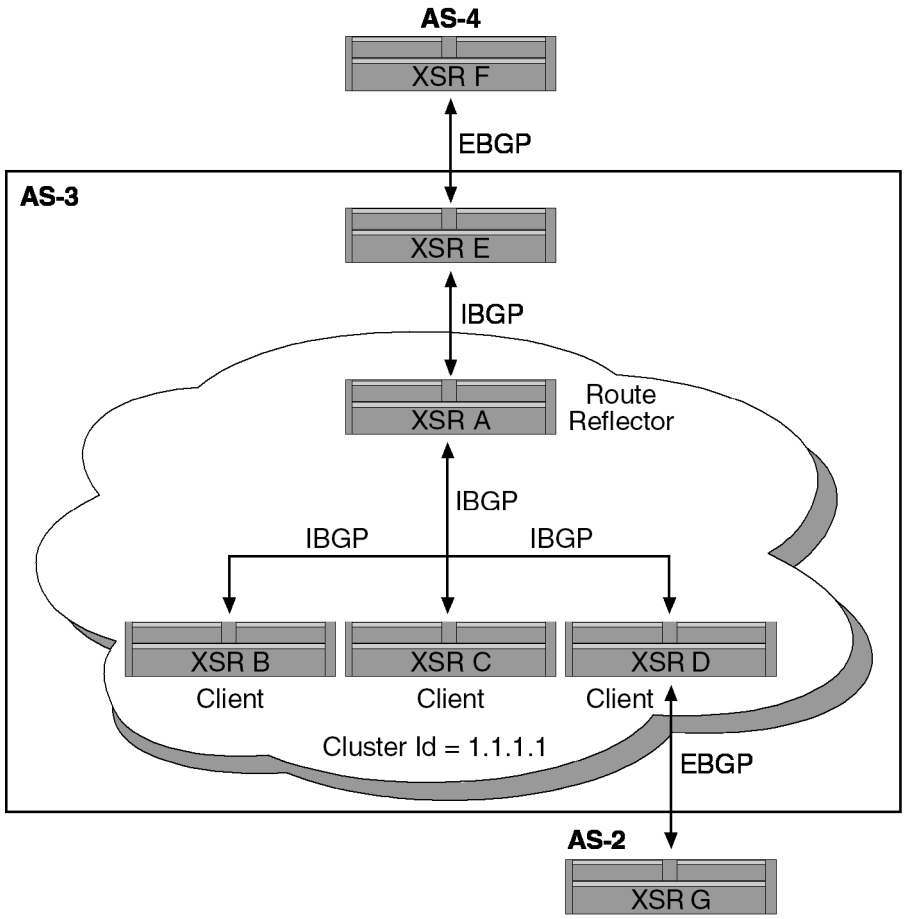
As an example, when an AS contains five routers as shown above, the number of BGP sessions needed is 10, as set by the equation: 5 x (5-1)/2 = 10.

Route Reflectors

Route reflectors are an alternative to the requirement of a fully meshed network within an AS, as illustrated in Figure 6-11. This approach allows a BGP speaker (known as a *route reflector*) to advertise IBGP learned routes to certain IBGP peers. This is a variation from the standard IBGP behavior of not re-advertising IBGP-learned routes to other IBGP speakers. But, if this rule is relaxed, the number of IBGP sessions can be greatly reduced.

This functionality is configured with the **`neighbor route-reflector-client`** command.

Figure 6-11 Route Reflector Applied to Minimize IBGP Mesh



As there are route reflector- compliant BGP speakers, some BGP speakers may not comply with route reflector behavior. They can be either client or non-client group members. This situation does not prohibit configuring reflectors, though. At first, you can configure one cluster with a route reflector and some clients. You can consider all other IBGP speakers non-client peers to the route reflector and add more clusters.

More than one route reflector can be associated with an AS. As such, a route reflector treats other reflectors similar to other IBGP speakers and it can be configured to include other reflectors in a client or non-client group. A rudimentary scenario would divide the backbone into multiple clusters and each route reflector configured with other route reflectors as non-client peers (fully meshing all reflectors). Clustered clients would be set up to keep IBGP sessions going with only the reflector within.

It is typical for a client cluster to have one route reflector and be identified by the reflector's router ID. If you want greater redundancy and wish to avoid a single point of failure, you can add more than one reflector to a cluster. This is accomplished by configuring all cluster route reflectors with the 4-byte cluster ID so that a reflector can recognize updates from other reflectors within that cluster. All reflectors serving a cluster should be fully meshed and share identical client and non-client peer groups.

For clusters with multiple route reflectors, specify the cluster ID with the **`bgp cluster-id`** command

A route reflector's clients, by default, need not be fully meshed so a client's routes are reflected to others. But if clients are *fully meshed*, the route reflector need not reflect routes to clients and you can disable client-to-client route reflection with the **`no bgp client-to-client reflection`** command.

To avoid routing data loops, which may arise from reflected IBGP learned routes, the XSR supports the following options:

- *Originator-ID*, a 4-byte attribute created by a route reflector. This automatically generated attribute holds the router ID of the route's originator in the local AS. If a misconfiguration causes routing data to bounce back to the originator, the data is dropped.
- *Cluster-list* is an optional BGP attribute configured with the **`bgp cluster-id`** command. It is a series of cluster IDs the route has passed. When a route reflector reflects a route from its clients to non-client peers, it appends the local cluster ID to the cluster-list, and if empty, it creates a new ID. With this attribute, a reflector can determine if routing data is mistakenly looped back to the same cluster. If the local cluster ID is found in the cluster-list, the advertisement is dropped.
- *Set clauses* employed in outbound route maps change attributes and risk routing loops. The XSR avoids this by ignoring these set clauses for routes reflected to IBGP peers.

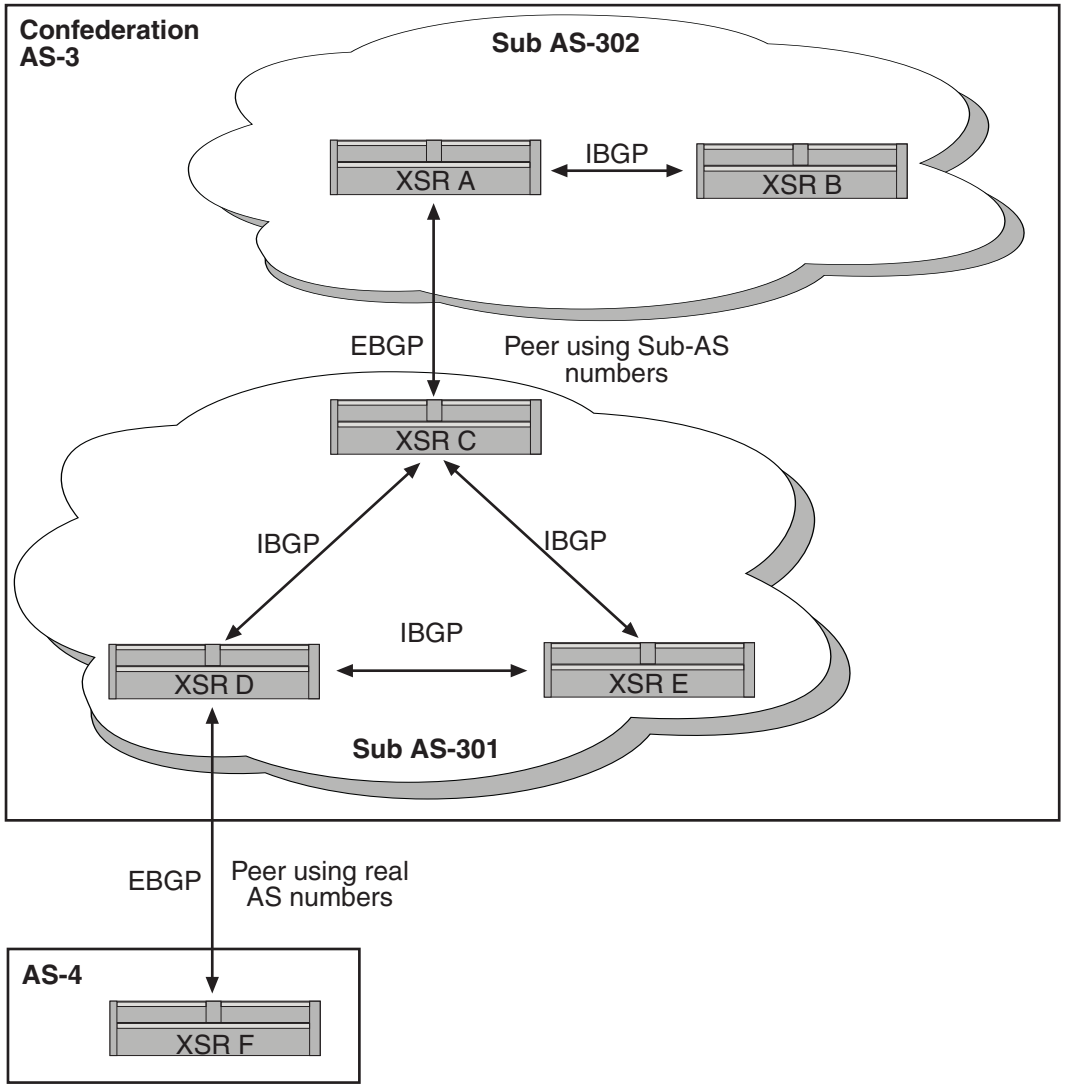
Confederations

Confederations are another alternative to the fully meshed requirement within an AS, as shown in Figure 6-12. This is accomplished by dividing an AS with a host of BGP speakers into smaller domains or *confederations* and the peers in different AS's swapping routing data as if they were EBGP peers. By subdividing a larger AS, the number of intra-domain BGP connections are greatly reduced but the network still appears as a single AS to its external EBGP peers.

Confederations require a confederation identifier (an AS number) for what will appear as a single AS to exterior networks; it is set with the **`bgp confederation identifier`** command. Neighbors from other AS's within the confederation are marked as special EBGP peers with the **`bgp confederation peers <AS#>`** command.

For an example, refer to "Configuring BGP Confederations" on page 6-24. Alternatively, you can also downsize the IBGP mesh with route reflectors, described on page 6-19.

Figure 6-12 Figure 12 Use of Confederations to Reduce IBGP Mesh



Displaying System and Network Statistics

The XSR supports BGP statistical displays such as routing table entries, caches, and databases. The XSR can also show data about node accessibility and the path packets take through the network. The XSR offers the following BGP **show** commands:

- Show BGP routing table entries: **show ip bgp**
- Show routes within communities: **show ip bgp community**
- Show routes sanctioned by a community list: **show ip bgp community-list**
- Show paths suppressed due to dampening: **show ip bgp dampened-list**
- Show routes matched by the AS path ACL: **show ip bgp filter-list**
- Show routes with conflicting originating ASs: **show ip bgp inconsistent-as**
- Show data on a neighbor's TCP and BGP links: **show ip bgp neighbors**

- Show BGP peer group data: **show ip bgp peer-group**
- Show routes matching regular AS path expressions: **show ip bgp regexp**
- Show summary BGP neighbor status: **show ip bgp summary**

Configuring BGP Route Maps

The following example illustrates the use of a *route map* to modify inbound data from a neighbor. Any route received from 192.168.10.1 matching the filter values set in AS ACL 110 will be permitted with its weight set to 55 and its local preference set to 60. Note the use of regular expressions.

```
XSR(config)#router bgp 1
XSR(config-router)#neighbor 192.168.10.1 route-map 55 in
XSR(config-router)#neighbor 192.168.10.1 remote-as 1
XSR(config-router)#route-map 55 permit 5
XSR(config-route-map)#match as-path 110
XSR(config-route-map)#set local-preference 60
XSR(config-route-map)#set weight 55
XSR(config-route-map)#ip as-path access-list 110 permit ^650$
XSR(config-route-map)#ip as-path access-list 110 permit ^700
```

In the following example, route map *99* marks all paths originating from AS 57 with a MED metric attribute of 99. The second permit clause is needed so that routes not matching AS path list 1 will all be relayed to neighbor 192.168.10.1.

```
XSR(config)#router bgp 1
XSR(config-router)#neighbor 192.168.10.1 route-map 99 out
XSR(config)#exit
XSR(config)#ip as-path access-list 1 permit ^57_
XSR(config)#ip as-path access-list 2 permit .*
XSR(config)#router bgp 1
XSR(config-router)#route-map 99 permit 5
XSR(config-route-map)#match as-path 1
XSR(config-route-map)#set metric 99
XSR(config-route-map)#route-map 99 permit 10
XSR(config-route-map)#match as-path 2
```

BGP correctly does not accept any AS path not matching the match clause of the route map. This means that you will not set the metric and the XSR will not accept the route. But, you can configure the router to accept AS paths not matched in the match clause of the route map command by using multiple maps of the same name, some without accompanying set commands.

```
XSR(config-router)#route-map 44 permit 8
XSR(config-route-map)#match as-path 1
XSR(config-route-map)#set local-preference 3
XSR(config-route-map)#route-map 44 permit 12
XSR(config-route-map)#match as-path 2
```

In the following example, route map *77* is assigned to outgoing updates for neighbor 192.168.57.4. Route map 77 will prepend AS path 100 to routes that pass ACL 12. The remaining route map configuration allows other routes to be advertised.

```
XSR(config)#router bgp 33
XSR(config-router)#network 230.57.10.0
XSR(config-router)#network 231.57.10.0
```

```
XSR(config-router)#neighbor 192.168.57.4 remote-as 200
XSR(config-router)#neighbor 192.168.57.4 route-map 77 out
XSR(config-router)#route-map 77 5 permit
XSR(config-route-map)#set as-path prepend 100
XSR(config-route-map)#match ip address 12

XSR(config-route-map)#route-map 77 15 permit
XSR(config-route-map)#match ip address 2
XSR(config-route-map)#access-list 2 permit any
XSR(config-route-map)#access-list 12 permit 230.57.10.0 0.255.255.255
XSR(config-route-map)#access-list 12 permit 231.57.10.0 0.255.255.255
XSR(config-route-map)#access-list 12 permit 0.0.0.0 255.255.255.255
```

Incoming route-maps can perform prefix-based matching and set various update values. Inbound prefix matching is provided in addition to *as-path* and *community-list* matching. In the following example, the set local preference command sets the local preference of the inbound prefix 230.57.5.0/16 to 95.

```
XSR(config)#router bgp 13
XSR(config-router)#network 192.168.0.0
XSR(config-router)#neighbor 192.168.1.1 remote-as 47
XSR(config-router)#neighbor 192.168.1.1 route-map 33 in !
XSR(config-router)#route-map 33 permit 5
XSR(config-route-map)#match ip address 2
XSR(config-route-map)#set local preference 95
XSR(config-route-map)#route-map 33 permit 9
XSR(config-route-map)#access-list 2 permit 230.57.5.0
XSR(config-route-map)#access-list 20.255.255.255 access-list 2 deny any
```

Configuring BGP Neighbors

This example configures a BGP router for AS 33 including two originating networks and three remote XSR's. The XSR at AS 33 will share data about networks 125.99.0.0 and 192.168.57.0 with its neighbors. The first router listed exists in a different AS; the second is an internal neighbor (AS 33) at address 125.99.28.2; and the third neighbor also exists on a different AS.

Note that the inside BGP neighbor is not directly linked to XSR A. External neighbors (in AS 22 and AS 44) must be linked directly to Router A.

```
XSR(config)#router bgp 33
XSR(router-config)#network 125.99.0.0
XSR(router-config)#network 192.168.57.0
XSR(router-config)#neighbor 125.99.27.1 remote-as 22
XSR(router-config)#neighbor 125.99.28.2 remote-as 33
XSR(router-config)#neighbor 212.106.53.9 remote-as 44
```

BGP Path Filtering by Neighbor Example

This example configures BGP path filtering by neighbor where only routes permitted by as-path ACL 2 will be sent *to* 192.168.57.69. In the same fashion, only routes passing ACL 3 will be permitted *from* 192.168.57.69.

```
XSR(config)#router bgp 7
XSR(config-router)#neighbor 192.168.57.69 remote-as 100
```

```
XSR(config-router)#neighbor 192.168.57.69 filter-list 3 out
XSR(config-router)#neighbor 192.168.57.69 filter-list 2 in
XSR(config-router)#exit
XSR(config)#ip as-path access-list 1 permit _102_
XSR(config)#ip as-path access-list 2 permit _200$
XSR(config)#ip as-path access-list 2 permit ^100$
XSR(config)#ip as-path access-list 3 deny _440$
XSR(config)#ip as-path access-list 3 permit .*
```

BGP Aggregate Route Examples

The following examples describe how to use aggregate routes in BGP either by redistributing an aggregate route into BGP or by using the conditional aggregate routing feature.

In the next example, redistribute aggregate route 192.*.*.*:

```
XSR(config)#ip route 192.0.0.0 255.0.0.0 null 0
XSR(config)#router bgp 57
XSR(config-router)#redistribute static
```

In the following example, add an aggregate entry in the BGP routing table when at least one route falls into the specified range. The XSR will advertise this route as originating from your AS and has the atomic aggregate attribute set to indicate data may be lost. (By default, atomic aggregate is set unless you use the *as-set* keyword in the **aggregate-address** command.)

```
XSR(config)#router bgp 57
XSR(config-router)#aggregate-address 192.0.0.0 255.0.0.0
```

Next, you add an aggregate entry using similar rules as in the previous example, but the path advertised for this route will be an AS_SET consisting of all elements within all paths being summarized:

```
XSR(config)#router bgp 57
XSR(config-router)#aggregate-address 192.0.0.0 255.0.0.0 as-set
```

The last example adds an aggregate route for 192.*.*.* and suppresses advertisements of more specific routes to all neighbors:

```
XSR(config)#router bgp 23
XSR(config-router)#aggregate-address 192.0.0.0 255.0.0.0 summary-only
```

Configuring BGP Confederations

The following example configures a confederation comprised of three internal AS's with AS numbers 1, 2, and 3. To BGP speakers outside the confederation, the confederation appears to be a standard AS with AS number 20 (set with the **bgp confederation identifier** command).

In a BGP speaker in AS 1, mark the peers from AS's 2 and 3 as special EBGP peers with the **bgp confederation peers** command. Peers 192.168.57.5 and 192.168.57.6 then will get the local-preference, next-hop and MED unchanged in updates. The router at 130.32.32.1 is a standard EBGP speaker and the updates it gets from this peer will be similar to a standard EBGP update from a peer in AS 20.

```
XSR(config)#router bgp 1
XSR(config-router)#bgp confederation identifier 20
XSR(config-router)#bgp confederation peers 2 3
XSR(config-router)#neighbor 192.168.57.5 remote-as 2
XSR(config-router)#neighbor 192.168.57.6 remote-as 3
```

```
XSR(config-router)#neighbor 130.32.32.1 remote-as 37
```

In a BGP speaker in AS 2, configure the peers from AS's 1 and 3 as special EBGP peers. Node 191.169.57.1 is a standard IBGP peer and 131.21.12.2 is a standard EBGP peer from AS 30.

```
XSR(config)#router bgp 2
XSR(config-router)#bgp confederation identifier 20
XSR(config-router)#bgp confederation peers 1 3
XSR(config-router)#neighbor 191.169.57.1 remote-as 2
XSR(config-router)#neighbor 192.168.57.7 remote-as 1
XSR(config-router)#neighbor 192.168.57.6 remote-as 3
XSR(config-router)#neighbor 132.21.12.2 remote-as 30
```

In a BGP speaker in AS 3, specify the peers from AS's 1 and 2 as special EBGP peers. Node 132.123.31.20 is a standard EBGP peer from AS 53.

```
XSR(config)#router bgp 3
XSR(config-router)#bgp confederation identifier 20
XSR(config-router)#bgp confederation peers 1 2
XSR(config-router)#neighbor 192.168.57.7 remote-as 1
XSR(config-router)#neighbor 192.168.57.5 remote-as 2
XSR(config-router)#neighbor 132.123.31.20 remote-as 53
```

The following example is a partial configuration from BGP speaker 132.123.31.23 from AS 53. Neighbor 192.168.57.5 is set up as a normal EBGP speaker from AS 45. Interior division of the AS into multiple AS's is unknown to peers outside the confederation.

```
XSR(config)#router bgp 53
XSR(config)#neighbor 192.168.57.5 remote-as 45
XSR(config-router)# 132.123.31.23 remote-as 53
```

TCP MD5 Authentication for BGP Example

The following example configures the XSR and its BGP peer at 192.168.57.5 perform MD5 authentication on their TCP link:

```
XSR(config)#router bgp 99
XSR(config-router)#neighbor 192.168.57.5 password 7&%kdeuj
```

Configuring BGP Peer Groups

This section details IBGP and an EBGP peer group examples.

IBGP Peer Group Example

Peer group *IBGP* comprises IBGP neighbors in this example. An IBGP peer group is stipulated by definition because the same AS is set by the **`router bgp`** and **`neighbor remote-as`** commands, AS 15). All peer group members share loopback 0 as the update source and route-map 3 as the outbound route-map. Also, except for the neighbor at address 192.168.57.5, all the neighbors have filter-list 2 as the inbound filter list.

```
XSR(config)#router bgp 15
XSR(config-router)#neighbor IBGP peer-group
XSR(config-router)#neighbor IBGP remote-as 15
XSR(config-router)#neighbor IBGP update-source loopback 0
XSR(config-router)#neighbor IBGP route-map 3 out
```

```
XSR(config-router)#neighbor IBGP filter-list 1 out
XSR(config-router)#neighbor IBGP filter-list 2 in
XSR(config-router)#neighbor 192.168.57.3 peer-group IBGP
XSR(config-router)#neighbor 192.168.57.4 peer-group IBGP
XSR(config-router)#neighbor 192.168.57.5 peer-group IBGP
XSR(config-router)#neighbor 192.168.57.5 filter-list 3 in
```

EBGP Peer Group Example

Peer group *EBGP* in this example is defined not using the **neighbor remote-as** command, rendering it an EBGP peer group by definition. Each peer group member is supplied with its respective AS number separately so the peer group is composed of members from AS's 25, 35, and 45. All peer group members have route map 5 as an outbound route map and filter-list 4 as an outbound filter list and all share incoming filter list 57 except neighbor 192.168.57.10.

```
XSR(config)#router bgp 13
XSR(config-router)#neighbor external-peers peer-group
XSR(config-router)#neighbor external-peers route-map 5 out
XSR(config-router)#neighbor external-peers filter-list 4 out
XSR(config-router)#neighbor external-peers filter-list 57 in
XSR(config-router)#neighbor 192.168.57.2 remote-as 25
XSR(config-router)#neighbor 192.168.57.2 peer-group external-peers
XSR(config-router)#neighbor 192.168.57.9 remote-as 35
XSR(config-router)#neighbor 192.168.57.9 peer-group external-peers
XSR(config-router)#neighbor 192.168.57.10 remote-as 45
XSR(config-router)#neighbor 192.168.57.10 peer-group external-peers
XSR(config-router)#neighbor 192.168.57.10 filter-list 45 in
```

BGP Community with Route Maps Examples

This section illustrates three examples of BGP communities with route maps. First, route map 111 is applied to outgoing updates for neighbor 192.168.57.50. The routes that pass ACL 1 share the no-export community attribute while other routes are advertised as usual. This community value automatically bars BGP speakers in AS 20 from advertising those routes.

```
XSR(config)#router bgp 10
XSR(config-router)#neighbor 192.168.57.50 remote-as 20
XSR(config-router)#neighbor 192.168.57.50 send-community
XSR(config-router)#neighbor 192.168.57.50 route-map 111 out

XSR(config-router)#route-map 111 10 permit
XSR(config-route-map)#match ip address 1
XSR(config-route-map)#set community no-export

XSR(config-route-map)#route-map 111 20 permit
XSR(config-route-map)#match ip address 2
```

Secondly, route map 111 is matched with outgoing updates for neighbor 192.168.57.90. All routes originating from AS 7 have the community values 50 50 added to their existing values with other routes advertised as usual.

```
XSR(config)#router bgp 20
XSR(config-router)#neighbor 192.168.57.90 remote-as 10
```

```
XSR(config-router)#neighbor 192.168.57.90 send-community
XSR(config-router)#neighbor 192.168.57.90 route-map 111 out

XSR(config-router)#neighbor route-map 111 10 permit
XSR(config-route-map)#match as-path 1
XSR(config-route-map)#set community 50 50 additive

XSR(config-route-map)#route-map 111 20 permit
XSR(config-route-map)#match as-path 2

XSR(config-route-map)#ip as-path access-list 1 permit 7$
XSR(config-route-map)#ip as-path access-list 2 permit .*
```

Thirdly, community-based matching selectively sets MED and local-preference values for neighbor 192.168.57.55's routes. All the routes that match community list 1 get a MED of 60 including any with communities *10 20 30* or *90 91*. These routes may have other community parameters too.

A local preference of 30 is set for all routes that pass community list 2 including those with community values 8 or 9. If the routes belong to any other community, no matching by community list 2 is done.

A local preference of 40 is set for all routes matching community list 3 which matches all the routes because they are members of the Internet community. So, the remainder of neighbor 192.168.57.55's routes get local preference 40.

```
XSR(config)#router bgp 20
XSR(config-router)#neighbor 192.168.57.55 remote-as 10
XSR(config-router)#neighbor 192.168.57.55 route-map 101 in

XSR(config-router)#route-map 101 10 permit
XSR(config-route-map)#match community-list 1
XSR(config-route-map)#set metric 60

XSR(config-route-map)#route-map 101 20 permit
XSR(config-route-map)#match community-list 2
XSR(config-route-map)#set local-preference 30

XSR(config-route-map)#route-map 101 30 permit
XSR(config-route-map)#match community-list 3
XSR(config-route-map)#set local-preference 40
XSR(config-route-map)#exit
XSR(config)#ip community-list 1 permit 10 20 30
XSR(config)#ip community-list 1 permit 90 91
XSR(config)#ip community-list 2 permit 8
XSR(config)#ip community-list 2 permit 9
XSR(config)#ip community-list 3 permit internet
```

Route map 55 is applied to the outgoing updates for neighbor 192.168.57.50 in this example. Routes that pass ACL 1 have the special community attribute value *local-as,* with other routes advertised as usual. *Local-as* automatically prevents BGP speakers outside AS 20 from advertising those routes.

```
XSR(config)#router bgp 23
XSR(config-router)#network 1.0.0.0 mask 255.0.0.0
```

```
XSR(config-router)#bgp confederation identifier 100
XSR(config-router)#bgp confederation peer 10 20 30
XSR(config-router)#neighbor 192.168.57.50 remote-as 15
XSR(config-router)#neighbor 192.168.57.50 route-map 55 out
XSR(config-router)#neighbor 192.168.58.2 remote-as 10

XSR(config-router)#route-map 55 permit 10
XSR(config-route-map)#match ip address 1
XSR(config-route-map)#set community local-as
```

In the final example, confederation 100 holds three AS's: 10, 20, and 30. For network 2.0.0.0, the command **route map set-no-export** specifies that the routes advertised have the community attribute "no-export."

```
XSR(config)#router bgp 20
XSR(config-router)#bgp confederation identifier 100
XSR(config-router)#bgp confederation peer 10 20 30
XSR(config-router)#network 2.0.0.0 mask 255.0.0.0
XSR(config-router)#neighbor 192.168.57.1 remote-as 10
XSR(config-router)#neighbor 192.168.57.1 route-map 29 out
XSR(config-router)#set community no-export
```

7

Configuring PIM-SM and IGMP

This chapter describes Protocol Independent Multicast - Sparse Mode (PIM-SM) and Internet Group Management Protocol (IGMP) configuration.

Features

The XSR supports the following IGMP/PIM features:

- IGMP versions 1, 2 and 3 (on LAN interface only)
- PIM-SM version 2
- Static IGMP group membership
- Dynamic RP (BootStrap without Admin Scope Zone support)
- Static RP
- Register Mechanism
- Rendezvous Point Tree (RPT) Build-up
- Shortest Path Tree (SPT) Build-up
- RPT to SPT Switch
- Assert Mechanism
- Join/Prune Mechanism
- Source Specific Multicast (SSM) Support
- Multicast over GRE tunnel

Differences with Industry-Standard Approach

The XSR's implementation of IGMP differs from the industry-standard approach as follows:

- The XSR stipulates the RFC-3376 default Query interval of 125; the industry-standard value is 60.
- The XSR supports dynamic learning of the *robust* value and *query* interval from the received query message, as stipulated by RFC-3376, while the industry-standard router does not. The XSR also supports static configuration and the latest value, either learned dynamically or statically configured, will overwrite the previous value.

The XSR's implementation of PIM-SM differs from the industry-standard approach as follows:

- When sending a Register packet, the XSR calculates the checksum of the Register packet header only, in keeping with the RFC-2236 requirement. The industry-standard router

calculates the checksum based on the whole Register packet including the data portion. When the XSR receives a Register packet, it accepts both partial and whole checksum methods.

- The XSR permits configuration of the CRP value and sets the default priority value to 192, as required by the RFC. The industry-standard router uses a CRP of 0 - the highest priority - as the default value, and offers no command to change the priority value.

IP Multicast Overview

IP Multicast reduces traffic by simultaneously delivering a single stream of data to thousands of recipients. It is especially useful for video conferencing and corporate communications where traffic is significantly reduced.

IP Multicast traffic begins at its source with a single copy. Packets then flow down a Multicast Distribution Tree (MDT) and are replicated by routers in the network where branches split. The alternative approach requires a source to send multiple copies of the same data but traffic consumption can become unwieldy when the number of receivers grows. Since many duplicates share the same common path, it is sensible to send a single copy over this path and duplicate packets only when necessary.

The IP multicast architecture is distinguished by these components: multicast group management, multicast routing, and multicast traffic forwarding.

- *Multicast group management* records current users desirous of getting traffic addressed to a particular multicast group. PIM users or hosts have the flexibility to join or quit a multicast group at any time. IGMP operates within IPv4 networks for this purpose and IGMP version 3 users or hosts can specify the multicast group as well as the sources from which they want to receive particular multicast traffic.
- *Multicast routing* (MR) generates and maintains a loop-free multicast distribution tree for each multicast group over which multicast traffic flows. Further, the multicast routing module interacts with multicast group management such that when users or hosts want to join a group, the MR module will build a new or update an existing distribution tree to include them. DVMRP, PIM-DM and PIM-SM function for this purpose.
- *Multicast traffic forwarding* duplicates and forwards traffic according to the MDT for a particular multicast group.

Defining Multicast Group Addressing

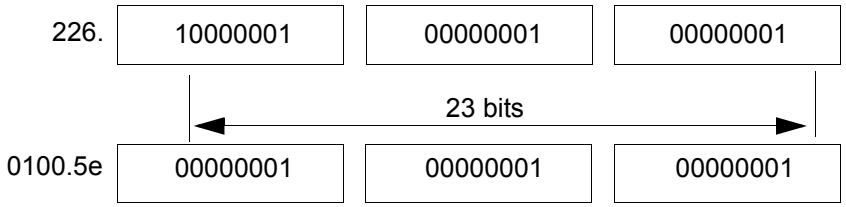
IP multicast traffic is recognized by destination IP addresses within the Class D address range. Each IP multicast address represents a multicast group. IPv4 multicast addresses are assigned directly by the Internet Assigned Numbers Authority (IANA). The current assignment of the IPv4 multicast addresses is located in RFC-3171. Some address ranges within Class D are reserved for special multicast services, such as the following.

- IP addresses ranging from 224.0.0.0 to 239.255.255.255 (Class D addresses) are designated multicast addresses.
- A multicast IP packet reaches a subset of all hosts on the network which have expressed an interest in the multicast group address.
- Addresses between 224.0.0.0 and 224.0.0.255 are reserved as link local addresses for use by network protocols on a local network segment and are never forwarded by any router.
- Addresses between 224.0.1.0 and 238.255.255.255 can be delivered throughout the Internet.

- Addresses between 239.0.0.0 and 239.255.255.255 should not be forwarded beyond an organization's intranet.
- Addresses between 232.0.0.0 and 232.255.255.255 are set aside especially for a Source-Specific Multicast service (SSM).

IP multicast enables multiple hosts to receive packets wrapped with the same MAC address: the IP multicast addresses are mapped directly into MAC addresses. In turn, network interface cards can receive packets destined to different MAC addresses. The MAC address range from *0100.5e00.0000* through *0100.5e7f.ffff* is the available range of Ethernet MAC addresses for IP multicast. The mapping rule for Ethernet is to place the lower **23** bits of the IP multicast group address into these available 23 bits in the Ethernet address. For example, the MAC address on Ethernet for IP multicast group 226.129.1.1 is *0100.5e01.0101*, as illustrated in Figure 7-1.

Figure 7-1 Sample IP Multicast Address Mapped to MAC Address



Outlining IGMP Versions

IGMP allows hosts and routers to report their IP multicast group memberships to neighboring multicast routers. In some circumstances, an IP multicast router may itself be a member of one or more multicast groups, in which case it performs both the multicast router role (to collect membership data) and the group member role (to inform itself and other neighboring multicast routers of its memberships). Presently, three versions of IGMP exist:

- IGMPv1(*RFC-1112*) was the first widely-deployed version and the first to become an Internet standard. It is supported on Windows 95.
- IGMPv2 (RFC-2236) added support for low *leave latency*, that is, a reduction in the period between the moment the last host leaves a group and when the routing protocol is notified that there are no more members). It also allows tuning the burstiness of IGMP traffic on a subnet. This version is supported on the latest service pack for Windows, newer Windows releases, and most UNIX systems.
- IGMPv3 *(DRAFT-IETF-IDMR-IGMP-V3-07)* added support for *source filtering*, permitting a system to report interest in receiving packets only from a specific source addressed, or from all but specific source addresses, sent to a particular multicast address. It is supported on FreeBSD patch, Linux patch, and Windows XP.

Comparing Multicast Distribution Trees

To reach packet receivers, multicast packets flow through Multicast Distribution Trees (MDTs) which are created by multicast-capable routers residing between the source and its receivers. Multicast group members can join or leave at any time, so distribution trees are dynamically updated. When all active receivers on a particular branch stop requesting traffic for a particular multicast group, the routers prune that branch from the distribution tree and stop forwarding it traffic. If one receiver on that branch later becomes active requesting multicast traffic, the router will modify the distribution tree on the fly and start re-forwarding traffic. Distribution trees are maintained by multicast routing protocols such as PIM.

Two basic types of MDTs are source and shared trees, described as follows:

- A *source tree* is a distribution network with its root at the source and branches forming a spanning tree through the network to its receivers. Because this tree uses the shortest path through the network, it is also referred to as a Shortest Path Tree (SPT). Different sources usually employ different distribution trees.
- A *shared* tree has a common root at a chosen site in the network called Rendezvous Point (RP). Different sources belonging to the same multicast group share the same distribution tree rooted at the RP.

Source trees consume more memory to store its states than shared trees but can often supply a better path from source to receivers with less delay.

The XSR generates and maintains MDTs with PIM, a set of popularly used multicast routing protocols. PIM derives its name from the fact that it is *IP routing protocol independent*. Although termed a multicast routing protocol, PIM uses the existing *unicast* routing table to perform multicast forwarding via the Reverse Path Forwarding (RPF) check function instead of building an independent multicast routing table. In this regard PIM can operate in two modes: PIM Dense Mode (PIM-DM) and PIM Sparse Mode (PIM-SM).

- *PIM-DM* uses a fairly simple approach to handle IP multicast routing. Assuming there are receivers at most locations for the multicast packet stream, PIM-DM starts by flooding multicast traffic, then stops at each link when an explicit stop request is received.
- By contrast, PIM-SM assumes relatively fewer receivers, sending multicasts only when requested to do so. PIM-SM is characterized by a combination of shared and shortest-path distribution trees. All group participants can use a shared distribution tree. Or the last hop routers can initiate a switch to shortest-path trees for certain sources when needed (for example, as data rates or delay requirements warrant, and scale permits).

Since PIM is unicast routing protocol-independent, PIM-SM uses *explicit joins* to build the multicast distribution tree that limits multicast traffic to only flow through the joined branches. And PIM-SM is flexible enough to change from a shared to source-based tree. These advantages make PIM-SM a better choice for *intra-domain* multicast service.

Forwarding Multicast Traffic

The XSR forwards multicast traffic as follows:

- When a multicast packet with source address *S* is received by a router, the packet will be forwarded only if it arrived on the interface to which the router would forward a unicast packet with destination address S. Otherwise, the packet is dropped. This is known as the Reverse Path Forwarding (RPF) test which is designed to prevent a forwarding loop since unicast routes are loop-free.
- Then the router will check the local distribution tree to get a list of outgoing interfaces, duplicate the packets, and send them to all outgoing interfaces.

Describing the XSR's IP Multicast Features

IGMPv3 is designed to enable each multicast router to learn, for each of its directly attached networks, which multicast addresses are of interest to the systems attached to those networks. IGMP version 3 adds the capability for a multicast router to also learn which sources are of interest to neighboring systems, for packets sent to any particular multicast address. The data gathered by IGMP is provided to whichever multicast routing protocol (e.g, PIM) is being used by the router, to ensure multicast packet delivery to all networks with interested receivers.

IGMP is an asymmetric protocol, so there are separate behaviors for group members (hosts or routers that wish to receive multicast packets) and multicast routers (routers that can forward multicast packets).

Group Membership Actions

Group members transmit *Report* messages to inform neighboring multicast routers of their multicast group states. Two types of events can trigger IGMPv3 protocol actions on an interface, a change in the *interface reception state*, and a *query reception*.

- A port reception state change is usually triggered by a higher-layer multicast program for video conferencing or network meetings. When you reconfigure these applications, that may change the multicast state triggering the system to send a state-change report from the associated interface. The type and contents of the group records in that report are determined by comparing the filter mode and source list for the affected multicast address before and after the change. The **`ip igmp join-group`** command simulates a host to join a specific multicast group.
- When the XSR receives a *Query*, it delays its response by a random interval - the *max resp time* value - derived from the *max resp code* in the received Query message. You can set this value in the sending router with the **`ip igmp query-max-response-time`** command. An XSR may receive a variety of Queries on different interfaces including *General Queries*, *Group-Specific Queries*, and *Group-and-Source-Specific Queries*, each of which may require its own delayed response. Before scheduling a response to a Query, the XSR must first consider previously scheduled pending responses and in many cases schedule a combined response.

Sending and Receiving Queries and Reports

Multicast routers send Query messages to and receive Report messages from group members. Multicast routers need know only that *at least one* system on an attached network is interested in packets to a particular multicast address from a source. The multicast router is not required to keep track of the interests of each individual neighboring system.

Sending a Query

Multicast routers periodically send General Queries to request group membership data from an attached network, a value which you can set with the **`ip igmp query-interval`** command. These queries help build and refresh the group membership state of attached systems which respond by reporting that state in IGMPv3 *Membership Reports*.

Multicast routers also transmit specific queries enabling all network systems to respond to group membership changes. Group-Specific Queries are sent to verify no systems want to receive the specified group or *rebuild* the desired reception state for a particular group. They are sent when a router gets a State-Change record indicating a system withdrawal from the group.

A Group-and-Source Specific Query verifies no network systems want traffic from a set of sources. It lists sources for a particular group which have been requested to no longer be forwarded. This query is sent by a multicast router to learn if any systems want to receive packets to the specified group address from the specified source addresses. These queries are sent only in response to *State-Change Records*, never in response to *Current-State Records*.

Receiving a Query

When a LAN contains multiple multicast routers, IGMPv3 chooses a single querier per subnet using the same querier election mechanism as IGMPv2, namely by *IP address*. When a router receives a query with a lower IP address, it sets the Other-Querier-Present timer to Other Querier Present Interval and stops sending queries on the network if it was the previously elected querier. After its Other-Querier Present timer expires, it will begin sending General Queries. If the previous querier stops sending queries, other multicast routers will wait a certain period, which can be configured by the **`ip igmp querier-timeout`** command, then take over as the querier.

Receiving a Report

Three types of group records comprise a Report message: *Filter-Mode-Change, Source-List-Change,* and *Current-State*. When multicast routers receive the Report message, they update the IGMP state table.

Source-Specific Forwarding Rules

When a multicast router receives a datagram from a source destined to a particular group, a decision must be made whether to forward the datagram onto an attached network or not. The multicast routing protocol makes this decision using IGMPv3 information to ensure that all sources/groups desired on a sub-network are forwarded to that sub-network. IGMPv3 data does not override multicast routing data; for example, if the IGMPv3 filter-mode group for *G* is *EXCLUDE*, a router may still forward packets for excluded sources to a transit subnet.

Interoperating with Older IGMP Versions

IGMPv3 hosts and routers can interoperate with hosts and routers that have not yet been upgraded to IGMPv3. This compatibility is maintained by hosts and routers taking appropriate actions depending on the versions of IGMP operating on hosts and routers within a network.

Query Version Distinctions

The IGMP version of a Membership Query message is determined as follows:

- IGMPv1 Query: length = 8 octets *and* Max Resp Code field is zero
- IGMPv2 Query: length = 8 octets *and* Max Resp Code field is non-zero
- IGMPv3 Query: length >= 12 octets

Query messages that do not match any of the above conditions (e.g., a Query of length 10 octets) will be silently ignored.

Behavior of Group Members Among Older Version Queriers

To be compatible with older version routers, IGMPv3 hosts operate in version 1 and version 2 compatibility modes. IGMPv3 hosts will keep state per local interface regarding the compatibility mode of each attached network. A host's compatibility mode is determined by the *Host Compatibility Mode* variable which can be in one of three states: IGMPv1, IGMPv2 or IGMPv3. This variable is stored per interface and is dependent on the version of General Queries received on that interface as well as the Older Version Querier Present timers set for the interface.

Behavior of Group Members Among Older Version Group Members

An IGMPv3 host may be situated in a network where hosts have not yet been upgraded to IGMPv3. A host *may* allow its IGMPv3 Membership Record to be suppressed by either a Version 1 or Version 2 Membership Report

Behavior of Multicast Routers Among Older Version Queriers

IGMPv3 routers may be sited on a network where at least one router on the network has not yet been upgraded to IGMPv3 with these requirements:

- If older versions of IGMP exist on routers, the querier *must* use the lowest IGMP version present on the network. This must be assured administratively; routers that desire to be compatible with IGMPv1 and IGMPv2 *must* have a configuration option to act in IGMPv1 or IGMPv2 compatibility modes which can be set with the **`ip igmp version`** command. When in IGMPv1 mode, routers *must* send Periodic Queries with a *Max Resp Code* of *0* and truncated at the Group Address field (i.e., 8-bytes long), and *must* ignore Leave Group messages. They should also log receipt of IGMPv2 or IGMPv3 queries. When in IGMPv2 mode, routers *must* send Periodic Queries truncated at the Group Address field (i.e., 8-bytes long), and should also log receipt of IGMPv3 queries. They also *must* fill in the *Max Resp Time* in the *Max Resp Code* field; that is, the exponential algorithm described is not used.
- If you do not explicitly configure a router to use IGMPv1 or IGMPv2 and it receives an IGMPv1 Query or IGMPv2 General Query, it should log a warning.

Behavior of Multicast Routers Among Older Version Group Members

IGMPv3 routers may be placed on a network where there are hosts that have not yet been upgraded to IGMPv3 but for compatibility with older version hosts, IGMPv3 routers *must* operate in version 1 and version 2 compatibility modes. IGMPv3 routers keep a record of compatibility mode by group, which is determined by the Group Compatibility Mode variable from one of three states: IGMPv1, IGMPv2 or IGMPv3. This variable is kept per group record and is dependent on the version of Membership Reports heard for that group as well as the Older Version Host Present timer for the group.

Describing the XSR's PIM-SM v2 Features

PIM-SM is a sparse-mode multicast routing protocol that uses a receiver-initiated process to build and maintain the MDT, as specified in *draft-ietf-pim-sm-v2-new-05*. A router running PIM-SM joins the construction of a MDT only when at least one of the hosts on its subnet requests membership in the specific multicast group. PIM-SM supports both shared and shortest-path trees (SPT) and can convert from shared to shortest-path tree based on network status to optimize multicast performance.

PIM-SM relies on another protocol to discover and collect network topology data and fill the Multicast Routing Information Base (MRIB). The MRIB is used by PIM-SM to learn how to reach other PIM-SM enabled routers. MRIB can derive from the unicast routing table filled by unicast routing protocols, such as RIP and OSPF, or it can be filled by another routing protocol tailored for multicast, such as MBGP. MRIB is also used to check against incoming multicast packets to ensure loop-free forwarding.

PIM-SM behavior can be described in three phases. Since senders and receivers can join or leave at any time, all phases may occur in parallel.

Phase 1: Building a Shared Tree

During phase one, PIM-SM builds a shared tree rooted at a special router called *Rendezvous Point* (RP), as shown in Figure 7-2. Each multicast group is mapped to a specific RP to which all *Designed Routers* (DR) of the receivers of the group send their join requests. All PIM-SM enabled routers within the PIM domain share uniform mapping between the multicast group and RP.

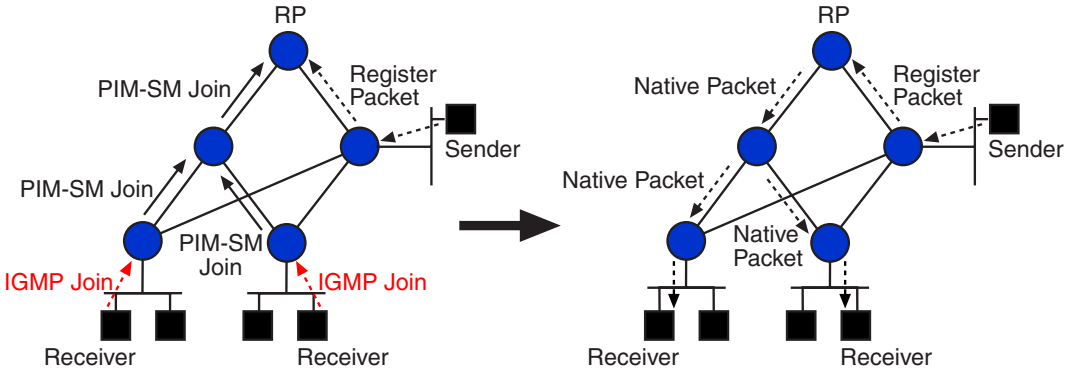
When a host wants to join a multicast group by using a group management protocol such as IGMP, the elected DR on its subnet will send a PIM *Join* message towards the RP of that multicast group by consulting the MRIB. The Join message will be processed hop by hop, and the path state will be pinned in the intermediate routers. The Join message will end on RP or a router already within the group. The paths the Join messages passed converge on RP forming a loop-free multicast distribution tree, which is shared by all multicast group receivers.

Periodically, the Join message is re-sent to upstream routers for RP to keep the router on the multicast tree. If a timeout occurs and there is still no Join message received by the upstream router, the Join state for that multicast group will be removed from the upstream router. If all receivers on the subnet leave the multicast group, the DR on that subnet will send a *Prune* message towards RP to remove itself from the multicast tree for that multicast group.

Senders are not required to be on the shared multicast tree. The DR on the subnet of the senders will encapsulate packets sent by the sender to the multicast group into a *Register* packet. Then the Register packet will be sent by the DR to RP for that multicast group as a *unicast* packet. When RP receives the Register packet, RP will decapsulate and send it down the shared multicast distribution tree.

At the end of phase one, packets sent from senders will be unicasted to RP in encapsulated Register packets and the native packets *multicast* over the shared distribution tree down to the receivers.

Figure 7-2 PIM-SM Phase 1 Topology: Shared Tree



Phase 2: Building Shortest Path Tree Between Sender & RP

Unicasting Register packets from multicast senders to RP is not efficient because:

- Encapsulating/decapsulating packets eats up router processing power
- Unicast routes may take a longer path from the sender to the multicast tree

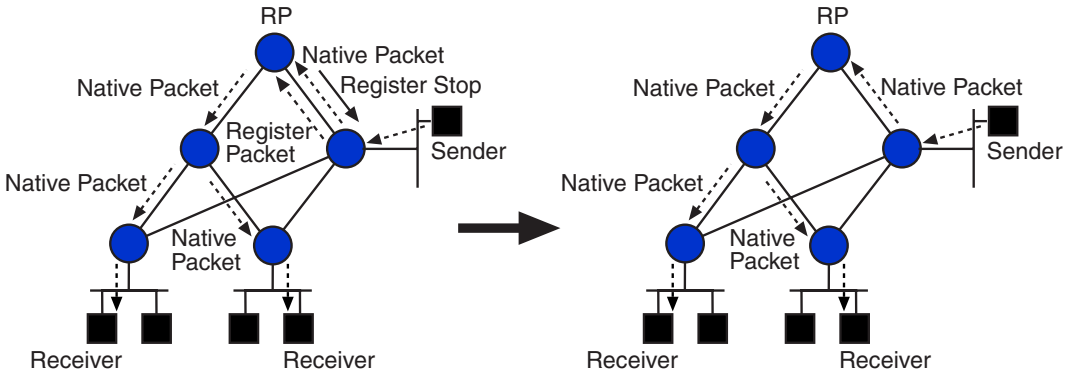
Usually, RP will initiate the process to build the shortest path tree between a sender and RP. When RP gets a Register packet from the DR of sender S, RP will send a Join message towards the S for that specific multicast group. The path passed by the Join message is pinned. If the path

interconnects with a router which is already on the shortest path tree from S to the same multicast group, the Join message can end on that router to get a short-cut path.

After the path is established, both the native packet along the SPT tree and Register encapsulated packet will be received by RP. When RP gets two copies of the same packet - one native and one encapsulated packet - it drops the encapsulated packet and sends a *RegisterStop* message back to the DR of S to let it know that it can now stop encapsulating packets in Register packets. After the DR of S receives the RegisterStop message, it starts a RegisterStop timer and stops encapsulating the packets until the RegisterStop timer expires.

At the end of phase two, packets flows natively from the sender to RP along the SPT tree, and then are passed by RP to all the receivers along the shared distribution tree., as illustrated in Figure 7-3.

Figure 7-3 Phase 2 Topology: Shortest Path Tree Between Sender and RP

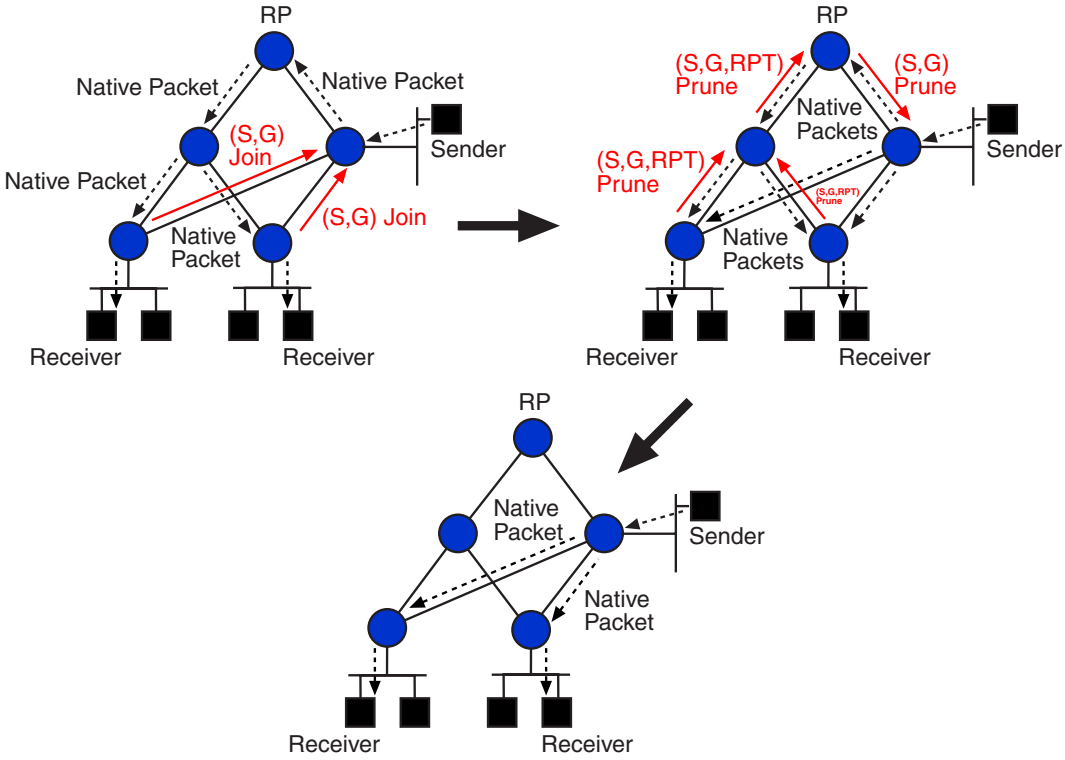


Phase 3: Building Shortest Path Tree Between Sender & Receiver

At the start of phase 3, the path from the sender to RP and on to the receiver is still not optimal for sender or receiver since some receivers may want to optimize the path between themselves and specific senders. In PIM-SM, the DR for the receiver has the flexibility to initiate a process to join the shortest path tree from the sender to the multicast group. To do so, the DR for the receiver desirous of optimizing the multicast path from sender S will send a *source-specific Join* message towards S. The path passed by the Join message will be pinned especially for traffic from S to the specific multicast group. After the SPT tree is set up between S and the DR of the receiver, traffic from S to that multicast group will flow both on the SPT tree and the shared RP tree. When the receiver can receive the same packet from both trees, the DR or upstream router for the receiver begins to drop the packet from the shared RP tree and sends a Prune message to tell the RP tree not to forward the traffic from the sender S for the specific multicast group.

After phase three, traffic from the sender will flow natively along the shortest path tree to the receiver, as shown in Figure 7-4.

Figure 7-4 Phase 3 Topology: Shortest Path Tree Between Sender and Receiver



Neighbor Discovery and DR Election

PIM-SM neighbor discovery and DR election are performed via Hello messages which are sent periodically through each PIM-enabled interface. A Hello Timer is kept for each interface whose timeout event will trigger sending a Hello message. You can set the interval between Hello messages with the **`ip pim query-interval`** command. Hello messages use the multicast address 224.0.0.13 (*ALL-PIM-ROUTERS*) as its destination address. Hello message must be sent out all PIM-active interfaces, including physical point-to-point ports. The Time-To-Live value of the Hello should be set to 1 with the **`ip multicast ttl-threshold`** command.

For each PIM interface, a PIM-enabled router keeps a list of active neighbors from which Hello messages are received. When the router receives Join/Prune or Assert messages from an interface, the sources of the messages are checked against the neighbor list for this interface. If the message does not come from one of its neighbors, it is dropped. So if a router needs to send a Join/Prune or Assert message to an interface on which it has not sent a Hello message, it should send a Hello message first without waiting for the Hello timer to expire. Before an interface goes down or changes its IP address, a Hello message with zero HoldTime should be sent immediately to let its neighbors immediately remove itself from their neighbor lists.

On each LAN, whether it is a shared media or point-to-point link, a Designated Router (DR) is elected to act on behalf of the hosts in the same LAN for PIM-SM. A DR is chosen from all active neighbors on the interface; if all have their DR priority (a 32-bit unsigned number within the Hello message) present, the one with the largest value is preferred. If there is more than one neighbor share the largest DR priority, the one with the largest IP address is selected as the DR. You can set DR priority with the **`ip pim dr-priority`** command.

PIM Register Message

By the end of PIM-SM phase one, the DR for the sender will encapsulate packets from the sender in a Register message and send it to RP for the multicast group. When the DR receives a RegisterStop message from RP, the RegisterStop timer will begin to maintain the state. Before the RegisterStop timer expires, the DR should send a empty Register message to RP so that RP will respond with another RegisterStop message. When the DR receives the RegisterStop message while the RegisterStop timer is still running, it restarts the RegisterStop timer so that no unnecessary Register messages are sent to RP. The IP ECN bits and DSCP bits of the original packet should be copied into the encapsulated Register packet.

PIM Join/Prune Message

To build and maintain the MDT, PIM-SM uses Join/Prune messages which contain a list of multicast groups and a list of Joined and Pruned sources for each multicast group. A PIM Join can be triggered by a new receiver joining the multicast group and is sent periodically from the downstream to upstream router to maintain the multicast tree. A timer controls the periodic sending of PIM Join messages which can be set with the **`ip pim message-interval`** command.

A PIM Prune can be triggered by the last receiver on a subnet exiting the multicast group. A source-specific Prune can be used to bar the shared RP Tree from forwarding traffic from the specific source. This type of Prune used for the RP tree should also be sent from the downstream to upstream router periodically to maintain state. When a router receives a PIM Prune message from its downstream router, it should start a *PrunePending* timer to wait for a period so that other downstream routers that are still interested in the traffic to override the Prune message with a Join message. It is performed to avoid unnecessary interruption of multicast traffic.

Bootstrap & Rendezvous Point

The bootstrap router is designed primarily to provide all routers in a domain with a common group for RP mappings. It is important for both sender and receiver to have a common tree for data distribution. The mechanism to distribute RP information is carried out using periodic *RP-Set* messages and *RP-Adv* messages. One *Bootstrap Router* (BSR) is elected within one domain among all routers that have been configured as Candidate BSRs. A router configured as the Candidate RP sends out periodic RP-Adv messages periodically to the elected BSR. This message contains the address of the other advertising Candidate RPs. When the elected BSR receives RP-Adv messages from different Candidate RPs, it hashes a list of RP to Class-D group mappings in a RP-Set message which is periodically sent hop by hop throughout the domain. In this way, all routers in the domain learn the same RP to group mappings, giving them a consistent view of which RP to send join/prunes and registered packets.

The bootstrap domain in which a uniform set of RP-to-group mapping is maintained can be defined by specifying the border interfaces of the bootstrap routers using the **`ip pim bsr-border`** command. Bootstrap router candidates can be configured with **`ip pim bsr-candidate`** and RP candidates can be defined with **`ip pim rp-candidate`**.

Assert Processing

On a shared LAN, it is possible for more than one upstream router in the MDT to forward the same multicast packet into the same LAN. Assert processing avoids duplicating multicast packets. Assert is triggered when a multicast data packet is received on an outgoing interface according to the constructed multicast tree. This occurs if there are two parallel routers sharing forwarding entries from the same group with outgoing packets directed toward the same LAN.

Assert messages are used to negotiate which router will forward the multicast packets. The rule for the assert winner is the router with the lower preference (usually a unicast routing protocol preference) and a metric learned from that protocol. If the preference is the same between the two parallel routers, then whichever router has the lower metric toward the source of the data packet will win out. If the metric is the same, the interface with the highest IP address wins the assert.

The XSR conducts assert processing automatically at the lowest topological level to service the end system network.

Source-Specific Multicast

Source-specific Multicast (SSM) was designed specifically for one-to-many multicast traffic. It collects subscriber data in a manner that it is much simpler than PIM-SM and can be implemented as a subset of the protocol. Both the regular IP multicast service and SSM service can coexist on the same router implemented by the protocol.

In SSM, delivery of datagrams is based on source specific (S, G) channels. Traffic for one (S, G) channel consists of datagrams with an IP unicast source address S and the multicast group address G as the IP destination address. Systems will receive this traffic by becoming members of the (S, G) channel. No signaling is required to become a source. But, in SSM, receivers must subscribe or unsubscribe to (S, G) channels to receive or not receive traffic from specific sources. In other words, receivers can receive traffic only from (S, G) channels that they are subscribed to. The proposed standard approach for channel subscription signaling utilizes IGMP INCLUDE mode membership reports, which are only supported in Version 3 of IGMP. The IP address range from 232.0.0.0 to 232.255.255.255 is reserved especially for SSM service. A receiver is also allowed to issue an (S,G) join request in the non-SSM address range; but, in that case there is no guarantee that it will receive service according to the SSM model.

PIM SM over Frame Relay

Frame Relay networks are not normally fully meshed but they appear to the IP layer as a logical LAN network. This is a challenge to the XSR's implementation of multicast functionality because when a prune message is sent from one remote node to a central node, other remote nodes will not receive multicast prune packets and, therefore, none of the remote nodes will override the prune message. The central site will remove the Frame Relay interface from the outgoing list for the specified group when its timer expires. Also, when a multicast data packet is sent from a remote node, other nodes will not receive the packet either. The XSR addresses this problem with a Point-to-Point solution.

For each remote node, the central site router configures a point-to-point sub-interface with its own IP address, thus mirrorings the behavior of multiple point to point interfaces. From the PIM perspective, no special processing is needed.

PIM Configuration Examples

The following is a simple PIM configuration using the virtual Loopback interface 0 and physical interface FastEthernet 1. Configuring a Loopback interface is a safer way to ensure PIM routers discover each other since specifying a physical IP address could result in a router being ignored if the network connection through that interface is down. On the other hand, configuring a physical interface is beneficial if you want a particular network path verified as connected. Only the following commands are required if you do not wish to change PIM default values.

```
XSR(config)#interface FastEthernet1
XSR(config-if<F1>)#ip address 192.168.49.2 255.255.255.0
XSR(config-if<F1>)#ip pim sparse-mode
XSR(config-if<F1>)#no shutdown

XSR(config)#interface Loopback0
XSR(config-if<L0>)#ip address 1.1.1.57 255.255.255.255
XSR(config-if<L0>)#ip pim sparse-mode
XSR(config-if<L0>)#no shutdown

XSR(config)#ip multicast-routing
XSR(config)#ip pim bsr-candidate Loopback0 30 57
XSR(config)#ip pim rp-candidate Loopback0 priority 57
```

8

Configuring PPP

Overview

The Point-to-Point Protocol (PPP), referenced in RFC-1616, is a standard method for transporting multi-protocol datagrams over point-to-point links. PPP defines procedures to assign and manage network addresses, asynchronous and synchronous encapsulation, link configuration, link quality testing, network protocol multiplexing, error detection, and option negotiation for network-layer address and data-compression negotiation. PPP provides all these functions through its three main components:

- An extensible Link Control Protocol (LCP) for establishing, configuring, and testing the data-link connection.
- A method for encapsulating multi-protocol datagrams.
- A family of Network Control Protocols (NCPs) for establishing and configuring different network-layer protocols.

When negotiation is complete, PPP becomes the *pipe* that carries the network layer protocol data units (PDUs) in the information field of the PPP packet. PPP offers high performance and error-free transmission of user traffic from sender to receiver over a link.

PPP Features

The XSR PPP software module offers the following features:

- IP datagram encapsulation over a data link connection
- Synchronous and asynchronous communication modes
- Multilink Protocol (MLPPP) as defined by RFC-1990
- Multi-Class MLPPP, as defined by RFC-2686. This option is present in the PPP LCP negotiation when enabled providing:
  - Multilink Maximum Received Reconstructed Unit (MRRU)
  - Multilink Short Sequence Number Header Format
  - Endpoint Discriminator
  - Maximum fragment delay
  - Fragment interleaving, reassembly, and transmission sequencing
  - Multi-Class option negotiation
- IPCP Network Control Protocol (NCP)
- Authentication of peer entities through:
  - Password Authentication Protocol (PAP)

  - Challenge Handshake Authentication Protocol (CHAP)
  - Microsoft Challenge Handshake Authentication Protocol (MS-CHAP)
- Link Quality Monitoring (LQM) procedures as defined by RFC-1989
- VJ/IP header compression
- No restriction on frame size; default is 1500 octets for the information field - as defined by RFC-1661
- Self-Describing Padding and FCS (16-bytes) as defined by RFC-1570
- Outbound Dialing
- 16-bit Fast Check Sequence
- The following parameters are negotiated during link level configuration (as defined by RFC-1471):
  - Maximum size of the packet that can be received on a link (MRU)
  - Protocol to be used for authentication
  - Asynchronous Character Control Map (ACCM)
  - The protocol to be used for Link Quality Monitoring
  - FCS
  - Magic number
  - Padding
- Bandwidth Allocation Protocol (BAP/BACP) as defined by RFC-2125
- PPP/MLPPP control packet debugging including protocol fields

Link Control Protocol (LCP)

The Link Control Protocol (LCP) handles the functions of establishing, configuring and terminating the PPP link. These functions are as follows:

- Establish, configure and terminate the PPP link.
- Initiate authentication and link quality monitoring procedures, if set.
- Initiate network layer configuration option negotiation procedures.

Link-level configuration options to be negotiated with the peer are set on per-link basis. After the lower layer is operationally up, link establishment and configuration negotiation is performed. If a configuration option is not included in the LCP packet, the default value for that option is assumed. LCP starts authentication and LQM procedures after the link is built. After the link is authenticated successfully, configured NCP protocols are initiated.

Network Control Protocol (NCP)

The Network Control Protocol (NCP) handles transmission and reception of various network layer control packets and datagrams. NCP provides:

- Sets up network layer control protocols over the established PPP link.
- Sends/receives network layer datagrams if the corresponding NCP is successfully negotiated.

The configuration negotiation procedures are performed once the LCP reaches the OPENED state.

Authentication

Authentication protocols, as referenced in RFC-1334, are used primarily by hosts and routers to connect to a PPP network server via switched circuits or dialup lines, but might be applied to dedicated links as well. The server can use identification of the connecting host or router to select options for network layer negotiations.

The authentication protocol used is negotiated with the peer entity via LCP configuration options. If the authentication option is successfully negotiated, the LCP module initiates authentication after link establishment. This module performs authentication and the result is communicated to the LCP module. If authentication succeeds, LCP informs NCP that the PPP link is operational. If authentication fails, it closes the PPP link and generates an error message.

Password Authentication Protocol (PAP)

The Password Authentication Protocol (PAP) is a simple method for the peer to establish its identity using a two-way handshake. PAP authentication occurs only upon initial link establishment. After this phase is complete, the peer repeatedly sends an ID/Password pair to the authenticator until authentication is acknowledged or the connection closed.

PAP is not a strong authentication method because passwords are sent over a circuit *in the clear* with no protection from playback or repeated trial and error attacks. The peer controls the frequency and timing of authentication tries.

PAP is most appropriate where a plaintext password must be available to simulate a login at a remote host. In such a use, PAP provides a similar level of security to the usual user login at the remote host.

Challenge Handshake Authentication Protocol (CHAP)

The Challenge Handshake Authentication Protocol (CHAP), as referenced in RFC-1994, periodically verifies the identity of the peer using a 3-way handshake. This occurs upon initial link establishment, and may be repeated anytime after the link has been established.

After the link establishment phase is complete, the authenticator sends a “challenge” message to the peer. The peer responds with a value calculated using a “one-way hash” function.

The authenticator checks the response against its own calculation of the expected hash value. If the values match the connection is accepted, otherwise the connection is ended. CHAP uses MD5 as its hashing algorithm.

CHAP protects against playback attack with an incrementally changing identifier and a variable challenge value. The use of repeated challenges is intended to limit the time of exposure to any single attack. The authenticator controls the frequency and timing of the challenges.

CHAP depends upon a *secret* known only to the authenticator and that peer. The secret is not sent over the link. CHAP is most likely used where the same secret is easily accessed from both ends of the link.

Microsoft Challenge Handshake Protocol (MS-CHAP)

MS-CHAP, referenced in RFC-2433, authenticates remote Windows workstations, providing the functionality to which LAN-based users are accustomed while integrating the encryption and hashing algorithms used on Windows networks. MS-CHAP is closely derived from the PPP CHAP with the exception that it uses MD4 as its hashing algorithm.

The MS-CHAP challenge, response and success packet formats are identical in format to the standard CHAP challenge, response and success packets, respectively. MS-CHAP defines a set of *reason for failure* codes returned in the Failure packet Message Field.

It also defines a new packet called Change Password Packet, which enables a client to send a response packet based on a new password. An 8-octet challenge string is generated using a random number generator. A change password packet is sent in response to a failure packet from the peer that contains the failure code for change password.

Currently, MS-CHAP authenticators do not send the name value field in the challenge packet but construct the response packet with the first MS-CHAP name/secret pair retrieved from the secret list. When MS-CHAP secrets are not configured, a configure NAK will be sent with either CHAP (MD5) or PAP protocol in response to a MS-CHAP Authentication protocol option in the LCP request from the Windows system.

Link Quality Monitoring (LQM)

As referenced in RFC-1989, LQM defines a protocol for generating Link-Quality-Reports. These Report packets provide a mechanism to determine link quality, but it is up to each implementation to decide when the link is usable. LQM carefully defines the Link-Quality-Report packet format and specifies reference points to measure all data transmission and reception. LQM's functionality includes:

- Maintaining LQM statistics and sending them to the peer periodically
- Determining link quality based on statistics received from the peer
- Suspending traffic over the link, if that link quality is bad
- Monitoring suspended link quality by swapping LQM packets with peer
- Restoring the link after quality reaches a desired level (configurable)

Multilink PPP (MLPPP)

Multilink PPP (MLPPP), as defined in RFC-1990, aggregates multiple point-to-point links to form a group with higher bandwidth. Multilink is based on an LCP option negotiation that permits the XSR to indicate to its peer that it is capable of combining multiple physical links into a *bundle*.

LCP negotiation indicates the following:

- The XSR can combine multiple physical links into one logical link
- The XSR can receive upper layer protocol data units (PDU) fragmented using the multilink header and reassemble the fragments into the original PDU for processing
- The XSR can receive PDUs of size *N* octets where *N* is specified as part of the option even if *N* is larger than the maximum receive unit (MRU) for a single physical link

  Note: The XSR does *not* support Multilink PPP bundles between unchannelized T3/E3 ports. Multilink PPP bundles *are* supported on T1/E1 ports of channelized T3/E3 ports, but are limited to a single T3/E3 port; that is, a Multilink PPP bundle between T1/E1s of different channelized T3/E3 ports is not supported.

When a packet is transmitted over a multilink bundle it is encapsulated by a multilink header, which includes information to allow the packets sent over the links in the bundle to be sequenced.

Functionality provided by MLPPP on the XSR includes:

- Learned number of fragments to be sent on each link and the bundle

- Fragmentation/reassembly
- Detection of fragment loss
- Optimal buffer usage
- MTU size determination
- Management of MLPPP bundles
- MIB support for network management
- Up to four T1/E1 lines can be aggregated running MLPPP
- Multi-class MLPPP for up to five multiple sequence number streams over one MLPPP bundle

Multi-Class MLPPP

The Multi-Class extension to Multi-link PPP, as defined by RFC-2686, provides a means of transmitting multiple sequence traffic streams over one Multi-link PPP bundle on a Multilink or Dialer interface. Multi-Class offers *best-effort* Quality of Service (QoS) to minimize delay and fully utilize bandwidth over each member link ensuring that high priority traffic such as real-time voice and video packets is transmitted with minimum delay. The XSR's implementation of Multi-Class MLPPP supports the following features:

- Multilink Maximum Received Reconstructed Unit (MRRU). This non-configurable feature is set to 1500 bytes by default.
- Multilink Short Sequence Number Header Format is non-configurable but allows lower priority traffic classes to be *suspended* in favor of higher priority classes when necessary. The XSR defaults to the *long sequence number* header format but is passive - if a peer requests the *short* format the router provides a short sequence number. The Suspendable (class) level for negotiation is defaulted to 5. The XSR will accept any lower Suspendable (class) level negotiation and reject any larger levels.
- Endpoint Discriminator is configurable to specify a class with the **`ppp multipoint endpoint`** command.
- Multilink Header Format is enabled with the **`ppp multilink multi-class`** command.

The benefits of operating Multi-Class MLPPP are as follows:

- Fragment interleaving with different classes (priorities).
- Multiple suspension (class) layers to accommodate multiple priority classifications and packet interleaving.
- Full bandwidth utilization across the bundle since all fragments with different priorities can be sent over any member link without violating the order of packets sharing the same classification.

Multi-Class is limited in that it does not provide a method for packet classification, relying on an external method - QoS - to prioritize the output packet stream with certain criteria. QoS currently supports up to four types of classification via ACLs. While MLPPP supports sending packets outside MLPPP with no fragmentation and no MLPPP header by default, the total level of prioritization supported is five for QoS, the same as that (four suspendable levels) available in Multi-Class MLPPP.

If the negotiated Multi-Class level is less than the number of classes set by QoS, MLPPP will fit the QoS class type into the MLPPP Multi-Class number according to the principle that the higher priority QoS class type will fit into a higher Multi-Class class until the Multi-Class number 0, which will contain any remaining QoS low priority classes.

MLPPP Packet Fragmentation and Serialization Transmission Latency

MLPPP's packet transport method over multiple member links is made possible by fragmenting the packet after balancing the load bandwidth to fully utilize the member links' bandwidth. When sent over a MLPPP link, each fragment carries a *sequence* number within the Multilink header, as shown in Figure 8-5, to ensure that fragment is reassembled and forwarded to higher layer applications in the same order.

Figure 8-5 Multilink Header Option Format

Additionally, each fragment of a sequence stream is assigned a *class* number in the MLPPP header, permitting at most four classes for the short and 16 for the long sequence number fragment. The higher the class number, the higher the priority it is granted over the line. For example, voice, video and data packets can be assigned high, medium and low priority sequence numbers to ensure proper QoS. Refer to "Configuring Quality of Service" on page 12-1 for more information.

Since standard MLPPP allows only a single stream sequence number, the result is that only two priority level layers can be utilized without breaking the packet order as follows:

- *Higher* priority layer packets are sent *without* fragmentation and multilink headers.
- *Lower* priority layer packets are fragmented and interleaved with the higher priority packet.

MLPPP is marked by the following limitations:

- A higher priority packet can be sent through only one member link since it is not fragmented and does not contain a sequence number, otherwise the higher priority packet order can not be guaranteed.
- The bandwidth of the higher priority packet should not exceed the speed of the designated link used. The result is MLPPP bundle bandwidth is not fully utilized.

Each MLPPP packet holding a fragment is transmitted through the member link with packet transmission latency occurring as the result of packet size operating against link speed. With a Multi-link PPP connection, most packets are fragmented into equal size fragments and transmitted over all member links to balance bandwidth loading over each link with the same or different speeds. To sum up, fragment size must be controlled in order to minimize transmission latency. Serialization transmission latency, measured in milliseconds, equals fragment size (in bits) multiplied by link speed (in Kbps) as shown in Table 8-1.

Table 8-1 Serialization Latency for Different Fragment Size/Link Speed

	Fragment Size						
Link Speed	1 byte	64 bytes	128 bytes	256 bytes	512 bytes	1024 bytes	1500 bytes
56 kbps	143 us	9 ms	18 ms	36 ms	72 ms	144 ms	214 ms
64 kbps	125 us	8 ms	16 ms	32 ms	64 ms	126 ms	187 ms
128 kbps	62.5 us	4 ms	16 ms	32 ms	32 ms	64 ms	93 ms
256 kbps	31 us	2 ms	4 ms	8 ms	16 ms	32 ms	46 ms
512 kbps	15.6 us	1 ms	2 ms	4 ms	8 ms	16 ms	32 ms
768 kbps	10 us	640 us	1.28 ms	2.56 ms	5.12 ms	10.24 ms	15 ms

Table 8-1 Serialization Latency for Different Fragment Size/Link Speed (continued)

	Fragment Size						
1536 kbps	5 us	320 us	640 us	1.28 ms	2.56 ms	5.12 ms	10.24 ms
2024 kbps	4 us	256 us	512 us	1 ms	2 ms	4 ms	6 ms

The overall serialization latency for a fragment over a synchronous/ asynchronous Serial or T1 link should be multiplied by the size of the transmission queue. To control latency, both the transmission queue size and fragment size must be controlled.

Fragment Interleaving Over the Link

Transmitting a higher priority packet, either voice or video, with minimum and controlled latency, especially when lower priority packets such as data packets are present, is performed by the XSR automatically interleaving the fragment of the higher priority packet into the stream of the fragment of the lower priority packet. Fragment interleaving ensures that the transmission latency of a higher priority packet will not exceed the maximum value as determined by the sum of the fragment and transmission queue sizes.

To sum up, Multi-Class MLPPP performs as follows:

- Each packet is designated with a class number based on the classification result of the packet type. Packet classification is performed by the external method like QoS, which classifies the packet according to the ACL and assigns a class number according to priority as follows: the smaller the class number, the lower the priority. The current class number ranges from 1 to 4, with 1 for lower priority packets and 4 for the highest. Class 0 is reserved for a packet in the fair-queue class.
- Each packet is split into the small size. The maximum fragment size is defined as the maximum delay allowed over the slowest speed link in the bundle.
- Each fragment is appended with the MLPPP header, which includes the class information and sequence number dedicated to this class and transmitted over the member links. Fragments of different classes are interleaved.
- Fragments with a higher class number suspend the transmission of fragments with a lower class number that is pending for transmission, which is the interleaving of the fragments with different class numbers.
- When fragments are received, they are re-assembled based on class and sequence number with the order of the packet within the same class preserved.

Multilink Head Format Negotiation

The Multilink Head Format is negotiated between peers based on whether an MRRU, short sequence number, and code are *present*, as listed in Table 8-2 on page 8-7:

Table 8-2 Multi-Class MLPPP Negotiation

Option Type			
MRRU	Short Sequence #	Multilink Head Format	**Negotiation Result**
present	nil	nil	MLPPP with Long Sequence # & No Multi-Class
present	present		MLPPP with Short Sequence # & No Multi-Class
present	nil	present/Code = 2	MLPPP with Long Sequence # & Multi-Class

Table 8-2 Multi-Class MLPPP Negotiation (continued)

Option Type			
present	nil	present/Code = 6	MLPPP with Short Sequence # & Multi-Class
present	present	present	Not valid

The class number is defaulted to five for both short and the long sequence numbers. That includes four suspendable levels from 0 to 4 with the highest level at 5. The current limits on memory and throughput set the optimized number of class to 4 for the XSR.

The result of the number of suspendable classes after negotiation will set MLPPP to support up to that level of classes both for transmission and receipt. The suspendable level *could* differ between transmission and receipt depending on negotiation with the peer. For example, if the local peer is defaulted at a level of five classes and the remote peer has a level of two classes, following negotiation, the local peer could have two transmitting classes acknowledged by the remote peer and five receiving classes acknowledged by the remote peer.

Events and Alarms

Multi-Class Option Negotiation

When Multi-Class is enabled on MLPPP, every member under the bundle uses the same value to perform *negotiation*, and the member link under the bundle sets the negotiated value for Multi-Class, such as header format and suspendable level. The remainder of the member link must have same negotiated values, otherwise it will be rejected from joining the same bundle.

Multi-Class Receiving Packet

When a MLPPP packet is received with the class number outside the negotiated suspendable levels, as:

- A class number larger than the negotiated suspendable level,
- A non-zero class number is present when the non Multi-Class option is negotiated,

The packet is silently discarded and the discard count for the bundle statistics increased. Also, the following PPP debug message is generated:

```
MLPPP: Invalid Class Num
```

IP Control Protocol (IPCP)

IPCP negotiates the following options, as referenced in RFC-1332:

- The IP address of the system
- The compression protocol to be applied on IP datagrams (Van Jacobson Compressed TCP/IP)

Along with the above support, the following IPCP extension is also offered:

- Primary and Secondary DNS and NBNS address

Once negotiation is successful, IPCP allows IP traffic over the established PPP link. The negotiated IP addresses and MTU of the interface are passed on to the higher layer (IP) to update its tables.

IP Address Assignment

In PPP, IPCP configuration option type 3 corresponds to IP address negotiation. This configuration option provides a way to negotiate the IP address to be used on the local end of the link.

It allows the sender of the Configure-Request to state which IP address is desired, or to request that the peer provide the information. The peer can do this by NAKing the option, and returning a valid IP address. If the host wants the peer to provide the IP address, it will mark the IP address field as configuration option 0.

Upon receiving an IP-address Configure-Request with IP address field 0, IPCP may allocate a valid IP address to the peer by sending a Configure-Nak to the received Configure-Request or it may reject the Configure-Request.

PPP Bandwidth Allocation/Control Protocols (BAP/BAPC)

The XSR supports the PPP Bandwidth Allocation/Control protocols (BAP/BACP) as a means of managing individual links of a multilink bundle as well as specifying which peer is responsible for managing bandwidth during a multilink connection.

This ability to *dynamically change* bandwidth during a multilink connection is referred to as Bandwidth-on-Demand (BoD). For more information on BoD, refer to "Configuring Integrated Services Digital Network" on page 11-1 and "Configuring Dialer Services" on page 10-1.

BAP/BACP, as defined by RFC-2125, is a flexible, robust method of managing bandwidth between two peers. BAP does this by defining Call-Control packets and a protocol that allows peers to co-ordinate actual bandwidth allocation and de-allocation. Phone number values may be passed in the Call-Control packets to minimize user configuration.

BAP/BACP provides the following benefits:

- Allows multilink implementations to interoperate by providing call control through the use of link types, speeds, and telephone numbers.
- Controls thrashing caused by frequent raising/tearing down links.
- Ensures that both ends of a link are told when links are added/dropped from a multilink bundle.

The BACP protocol must reach the Opened state using the standard PPP mechanism as defined in RFC-1661. Once BACP reaches the Opened state on a bundle, BAP may transmit packets through this PPP/MLPPP pipeline.

BAP datagrams are encapsulated by the PPP/MLPPP module and transmitted across the link. Transmission and reception of BAP and BACP packets is through the same interface procedures used by any other NCP protocol pair.

Functionality provided by BAP/BACP is summarized as follows:

- To add links:
  - Negotiate phone numbers over the bundles through BAP.
  - Agree with peer before trying to set up a call.
  - Check for available lines before agreeing to add a link.
  - Manage race conditions when both peers wish to add a link.
- To delete links:
  - Agree with peer to tear down a link before disconnecting the call.

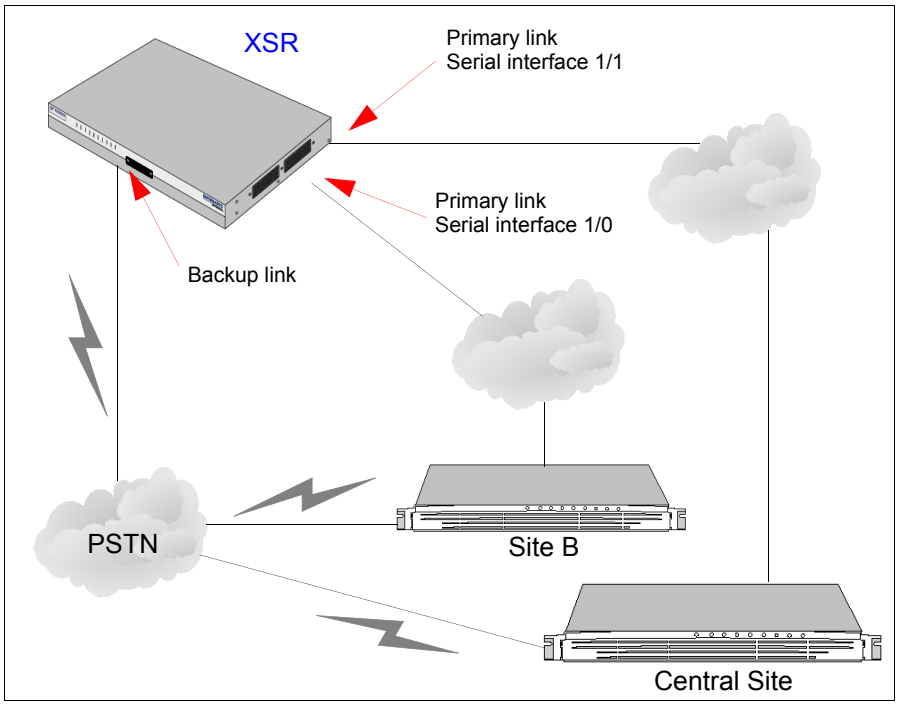
Configuring PPP with a Dialed Backup Line

You can configure PPP on the following types of physical interfaces:

- Asynchronous serial
- Synchronous serial
- T1/E1

By enabling PPP encapsulation on physical interfaces, PPP can also be used on calls placed by the dialer interfaces that use the physical interfaces. Refer to Figure 8-6 for an example of an XSR configured with one backup dial line to two different sites.

Figure 8-6 XSR Configuration with One Backup Dial Line to Different Sites



Configuring a Synchronous Serial Interface

Perform the following steps to configure a synchronous V.35 serial interface to communicate with PPP:

1. Enter **interface serial** <*card*/*port*> to specify the interface.

   ```
   XSR(config)#interface serial 1/0
   ```

2. Enter the media-type for the interface (default: RS232).

   ```
   XSR(config-if<S1/0>)#media-type v35
   ```

3. Enter **encapsulation ppp** to enable PPP encapsulation.

   ```
   XSR(config-if<S1/0>)#encapsulation ppp
   ```

4. Set the local IP address of this interface.

   ```
   XSR(config-if<S1/0>)#ip address 192.168.1.1 255.255.255.0
   ```

5. Enter **no shutdown** to enable this interface.

```
XSR(config-if<S1/0>)#no shutdown
```

Configuring a Dialed Backup Line

The following tasks must be performed to configure a Dialed Backup line:

- Configure the dialer interface
- Configure a physical interface to function as backup
- Configure primary interfaces to use a backup interface

Configuring the Dialer Interface

For more details on configuring Dialer Services, refer to *Chapter 7*.

1. Enter **interface dialer** *number* to create the dialer interface.

   The number range is 0 to 25.

2. Enter **encapsulation ppp** to enable PPP encapsulation.
3. Enter **ppp auth <options>** to set the type of authentication.

   The authentication options are chap, pap, or ms-chap.

4. Enter **ppp keepalive** *seconds* to set the keepalive interval.
5. Enter **ppp quality** *percentage* to set the minimum LQM value on the interface before it will go down.
6. Enter **dialer pool** *number* to specify the dialer pool.

   The number range is 0 to 255.

7. Enable the interface by entering the no shutdown command.

Configuring the Physical Interface for the Dialer Interface

1. Enter **interface serial** *card / port* to specify the interface.
2. Enter **encapsulation ppp** to set PPP encapsulation.
3. Enter **media-type {RS232 | RS422 | RS449 | RS530A | V35 | X21}** for the cable your interface connects to.

   The default media-type is RS232.

4. Enter **no shutdown** to enable the interface.
5. Enter **ppp max-bad auth** *number* to set the number of retries after which the interface resets itself.
6. Enter **dialer pool-member** *pool-number* **priority** *priority* to assign the interface as a member of the pool that the dialer interface will use.

   Pool-number is a value ranging from 0 to 255 specifying the pool. Priority is an optional value ranging from 0 to 255 that you can configure to prioritize this pool-member within the pool.

7. Enable the interface by entering the **no shutdown** command.

Configuring the Interface as the Backup Dialer Interface

1. Enter **interface serial** *card/port* to specify the interface to back up.
2. Enter **ip address** *ip-address mask* to specify the IP address and subnet mask of the interface.
3. Enter **backup interface dialer** *number* as the backup interface.
4. Enter **backup delay** *enable-delay disable-delay* to set the interval between the physical interface going down and the backup being enabled, and between the physical interface coming back up and the backup being disabled.
5. Enter **backup** *time-range start-time end-time* to set the time of day the backup interface should be enabled and disabled.
6. Enable the interface by entering the **no shutdown** command.

The CLI commands shown below configure the example shown in Figure 8-6 on page 8-10.

Configure interface *dialer 0* to use dial pool 5:

```
XSR(config)#interface dialer 0
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer pool 5
XSR(config-if<D1>)#no shutdown
```

Configure interface *dialer 1* to use dial pool 5:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ppp authentication chap pap
XSR(config-if<D1>)#dialer pool 5
XSR(config-if<D1>)#no shutdown
```

Configure serial port(s) for dial purposes and assign to dial pool 5:

```
XSR(config)#interface serial 1/2
XSR(config-if<S1/2>)#encapsulation ppp
XSR(config-if<S1/2>)#media-type v35
XSR(config-if<S1/2>)#dialer pool-member 5
XSR(config-if<S1/2>)#no shutdown
```

Configure the primary *serial port 1/0* to use dialer 1 as its backup interface:

```
XSR(config)#interface serial 1/0
XSR(config-if<S1/0>)#ip address 100.100.10.1 255.255.255.0
XSR(config-if<S1/0>)#encapsulation ppp
XSR(config-if<S1/0>)#backup interface dialer0
XSR(config-if<S1/0>)#no shutdown
```

Configure the primary *serial port 1/1* to use dialer 2 as its backup interface:

```
XSR(config)#interface serial 1/1
XSR(config-if<S1/1>)#backup interface dialer 1
XSR(config-if<S1/1>)#encapsulation ppp
XSR(config-if<S1/1>)#no shutdown
```

Configuring MLPPP on a Multilink/Dialer interface

Multilink Example

The following example enables Multi-Class MLPPP on interfaces 71, 72 and 73 with different fragmentation delay intervals but permits multicast traffic in and out of the firewall on each multilink interface. Additionally, Multilink interface 73 is configured to receive and transmit IP RIP v2 update packets.

```
XSR(config)#interface multilink 71
XSR(config-if<M71>)#ppp multilink fragment-delay 50
XSR(config-if<M71>)#ppp multilink multi-class
XSR(config-if<M71>)#ip address 15.1.2.70 255.255.255.0
XSR(config-if<M71>)#ip firewall disable
XSR(config-if<M71>)#ip firewall ip-multicast in
XSR(config-if<M71>)#ip firewall ip-multicast out
XSR(config-if<M71>)#no shutdown

XSR(config)#interface multilink 72
XSR(config-if<M72>)#ppp multilink fragment-delay 1000
XSR(config-if<M72>)#ppp multilink multi-class
XSR(config-if<M72>)#ip address 15.1.4.70 255.255.255.0
XSR(config-if<M72>)#ip firewall disable
XSR(config-if<M72>)#ip firewall ip-multicast in
XSR(config-if<M72>)#ip firewall ip-multicast out
XSR(config-if<M72>)#no shutdown

XSR(config)#interface multilink 73
XSR(config-if<M73>)#ppp multilink fragment-delay 650
XSR(config-if<M73>)#ppp multilink multi-class
XSR(config-if<M73>)#ip address 15.1.6.70 255.255.255.0
XSR(config-if<M73>)#ip firewall disable
XSR(config-if<M73>)#ip firewall ip-multicast in
XSR(config-if<M73>)#ip firewall ip-multicast out
XSR(config-if<M73>)#ip rip send version 2
XSR(config-if<M73>)#ip rip receive version 2
XSR(config-if<M73>)#no shutdown
```

Dialer Example

The following example enables Multi-Class MLPPP on Dialer interface 255 with dialer pool and BAP settings, Multi-Class fragment delay and load threshold values, and permission allowing multicast traffic in and out of the firewall on Dialer interface 255:

```
XSR(config)#interface dialer 255
XSR(config-if<D255>)#dialer pool 255
XSR(config-if<D255>)#dialer redial attempts 60000
XSR(config-if<D255>)#dialer string 9058883300
XSR(config-if<D255>)#dialer string 9058883400
XSR(config-if<D255>)#encapsulation ppp
XSR(config-if<D255>)#multilink load-threshold 190
```

```
XSR(config-if<D255>)#multilink min-links 37
XSR(config-if<D255>)#ppp multilink bap
XSR(config-if<D255>)#ppp bap number default 1200
XSR(config-if<D255>)#ppp bap number default 1400
XSR(config-if<D255>)#ppp bap call request
XSR(config-if<D255>)#ppp multilink fragment-delay 80
XSR(config-if<D255>)#ppp multilink multi-class
XSR(config-if<D255>)#dialer called 1200
XSR(config-if<D255>)#dialer called 1400
XSR(config-if<D255>)#dialer idle-timeout 1000000
XSR(config-if<D255>)#dialer watch-group 2
XSR(config-if<D255>)#ip address 200.3.8.21 255.255.255.0
XSR(config-if<D255>)#ip firewall ip-multicast in
XSR(config-if<D255>)#ip firewall ip-multicast out
XSR(config-if<D255>)#ppp keepalive 0
XSR(config-if<D255>)#no shutdown
```

Configuring BAP

The XSR is designed to provide Dial on Demand (DoD) functionality in addition to BAP, which is essentially an enhancement of Bandwidth on Demand (BoD). The router performs DoD when a *dialer map* and *dialer group* values are configured as well as *multilink PPP*.

One function central to DoD is the XSR's ability to perform LAN route *spoofing*, a means of maintaining routes in the routing table while keeping unused lines physically down.

The router brings up a line only when it receives a data packet and tears it down when idle timeout values are reached. Spoofing on the XSR is applicable to the dial out router only. Additional configuration includes specifying *call/callback request* (for BAP configurations) and *load threshold* (BoD) values.

On the XSR, DoD automatically brings up the first link if the router is the caller, and BAP negotiates raising the remaining links as they are needed.

The following tasks are required to configure BAP:

- Set up PRI/BRI physical interfaces
- Configure BAP values such as the load threshold and phone numbers

The following examples configure BAP, DoD, Call Request and Callback Request features on connected XSRs.

Dual XSRs: One Router Using DoD with Call Request

The following example sets up BAP on connecting XSRs over PRI and BRI interfaces with each capable of calling the other. The configurations are complimentary except only one XSR will add or remove links.

XSR1 Configuration

1. Begin configuring *XSR1* by setting up the *T1* controller (PRI interface):

```
XSR1(config)#controller t1 1/0
XSR1(config-controller<T1-1/0>)#pri-group
```

```
XSR1(config-controller<T1-1/0>)#isdn bchan-number-order ascending
XSR1(config-controller<T1-1/0>)#no shutdown
XSR1(config-controller<T1-1/0>)#dialer pool-member 1 priority 0
```

2. Configure BRI interface 2/0 with the *basic-ni1* switch type and two *SPIDs*:

```
XSR1(config)#interface bri 2/0
XSR1(config-if<BRI-2/0>)#isdn switch-type basic-ni1
XSR1(config-if<BRI-2/0>)#isdn spid1 0337250001
XSR1(config-if<BRI-2/0>)#isdn spid2 0337250101
XSR1(config-if<BRI-2/0>)#no shutdown
XSR1(config-if<BRI-2/0>)#dialer pool-member 1 priority 0
```

3. Configure the Dialer 1 interface with a dialer pool:

```
XSR1(config)#interface Dialer1
XSR1(config-if<D1>)#no shutdown
XSR1(config-if<D1>)#dialer pool 1
XSR1(config-if<D1>)#encapsulation ppp
```

4. Set up BAP on Dialer 1 by specifying the load-threshold (BoD), enabling BAP, and configuring *XSR1* to *initiate* the addition of a link. Note that the load threshold is very low, ensuring that BAP will be enabled relatively quickly when traffic starts to build.

```
XSR1(config-if<D1>)#multilink load-threshold 4
XSR1(config-if<D1>)#ppp multilink bap
XSR1(config-if<D1>)#ppp bap call request
```

5. Complete Dialer 1 configuration by setting the idle timeout and dialer-group values for DoD:

```
XSR1(config-if<D1>)#dialer idle-timeout 4000
XSR1(config-if<D1>)#dialer-group 2
XSR1(config-if<D1>)#ip address 99.99.1.2 255.0.0.0
```

6. Configure the dialer list and ACL for DoD:

```
XSR1(config-if<D1>)#access-list 102 permit icmp list 102
XSR1(config-if<D1>)#dialer-list 2 protocol ip list 102
```

XSR2 Configuration

XSR2 is configured to accept incoming calls only.

1. Begin configuring *XSR2* by setting up the *T1* controller (PRI interface):

```
XSR1(config)#controller t1 1/0
XSR2(config-controller<T1-1/0>)#pri-group
XSR2(config-controller<T1-1/0>)#isdn bchan-number-order ascending
XSR2(config-controller<T1-1/0>)#no shutdown
XSR2(config-controller<T1-1/0>)#dialer pool-member 1 priority 0
```

2. Configure BRI interface 2/0 with the *basic-ni1* switch type and two *SPIDs*:

```
XSR2(config)#interface bri 2/0
XSR2(config-if<BRI-2/0>)#isdn switch-type basic-ni1
XSR2(config-if<BRI-2/0>)#isdn spid1 0337250001
XSR2(config-if<BRI-2/0>)#isdn spid2 0337250101
XSR2(config-if<BRI-2/0>)#no shutdown
XSR2(config-if<BRI-2/0>)#dialer pool-member 1 priority 0
```

3. Configure the Dialer 1 interface with a dialer pool:

```
XSR2(config)#interface Dialer1
XSR2(config-if<D1>)#no shutdown
XSR2(config-if<D1>)#dialer pool 1
XSR2(config-if<D1>)#encapsulation ppp
```

4. Set up BAP on Dialer 1 by enabling BAP and adding BAP phone numbers for *XSR1* to call.

```
XSR2(config-if<D1>)#ppp multilink bap
XSR2(config-if<D1>)#ppp bap number default 3101
XSR2(config-if<D1>)#ppp bap number default 3102
XSR2(config-if<D1>)#ppp bap number default 3103
XSR2(config-if<D1>)#ppp bap number default 3104
XSR2(config-if<D1>)#ppp bap number default 3105
XSR2(config-if<D1>)#ip address 99.99.1.1 255.0.0.0
```

Dual XSRs: BAP Using Call/Callback Request

The following example sets up BAP between two XSRs, with XSR1 configured to perform Dial on Demand (DoD) and request additional links by sending a callback request to XSR2, which also is configured with DoD and requests additional links with call requests to XSR1.

XSR1 Configuration

```
XSR1(config)#controller e1 2/0
XSR1(config-controller<T1-2/0>)#pri-group
XSR1(config-controller<T1-2/0>)#no shutdown
!
XSR1(config)#interface Dialer1
XSR1(config-if<D1>)#no shutdown
XSR1(config-if<D1>)#dialer pool 1
XSR1(config-if<D1>)#encapsulation ppp
XSR1(config-if<D1>)#multilink load-threshold 3
XSR1(config-if<D1>)#ppp multilink bap
XSR1(config-if<D1>)#ppp bap number default 3200
XSR1(config-if<D1>)#ppp bap callback request
XSR1(config-if<D1>)#dialer-group 2
XSR1(config-if<D1>)#dialer map ip 10.10.10.2 1300
XSR1(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR1(config)#access-list 102 permit icmp any any 8
XSR1(config)#dialer-list 2 protocol ip list 102
```

XSR2 Configuration

```
XSR2(config)#controller e1 2/0
XSR2(config-controller<T1-2/0>)#pri-group
XSR2(config-controller<T1-2/0>)#no shutdown
XSR2(config-controller<T1-2/0>)#dial pool-member 1

XSR1(config)#interface Dialer1
XSR1(config-if<D1>)#no shutdown
```

```
XSR1(config-if<D1>)#dialer pool 1
XSR1(config-if<D1>)#encapsulation ppp
XSR1(config-if<D1>)#ppp multilink bap
XSR1(config-if<D1>)#ppp bap number default 1301
XSR1(config-if<D1>)#ppp bap number default 1300
XSR1(config-if<D1>)#ppp bap call request
XSR1(config-if<D1>)#dialer-group 2
XSR1(config-if<D1>)#dialer map ip 10.10.10.1 3200
XSR1(config-if<D1>)#ip address 10.10.10.2 255.255.255.0
!
XSR1(config)#access-list 102 permit icmp any any 8
XSR1(config)#dialer-list 2 protocol ip list 102
```

Further description of MLPPP and configuration of its various applications on the XSR can be found in "Configuring Dialer Services" on page 10-1 and "Configuring Integrated Services Digital Network" on page 11-1 in this manual, and the *XSR CLI Reference Guide*.

9

Configuring Frame Relay

Overview

Frame Relay (FR) is a simple, bit-oriented protocol that offers fast-packet switching for wide-area networking. It combines the statistical multiplexing and port-sharing features of an X.25 connection with fast speed and low delay for high performance and less overhead. Frame Relay organizes data into variable-length, individually addressed units known as *frames* rather than placing them in fixed time slots for delivery over a packet-switched network where the data channel is occupied only for the duration of the transmission.

Virtual Circuits

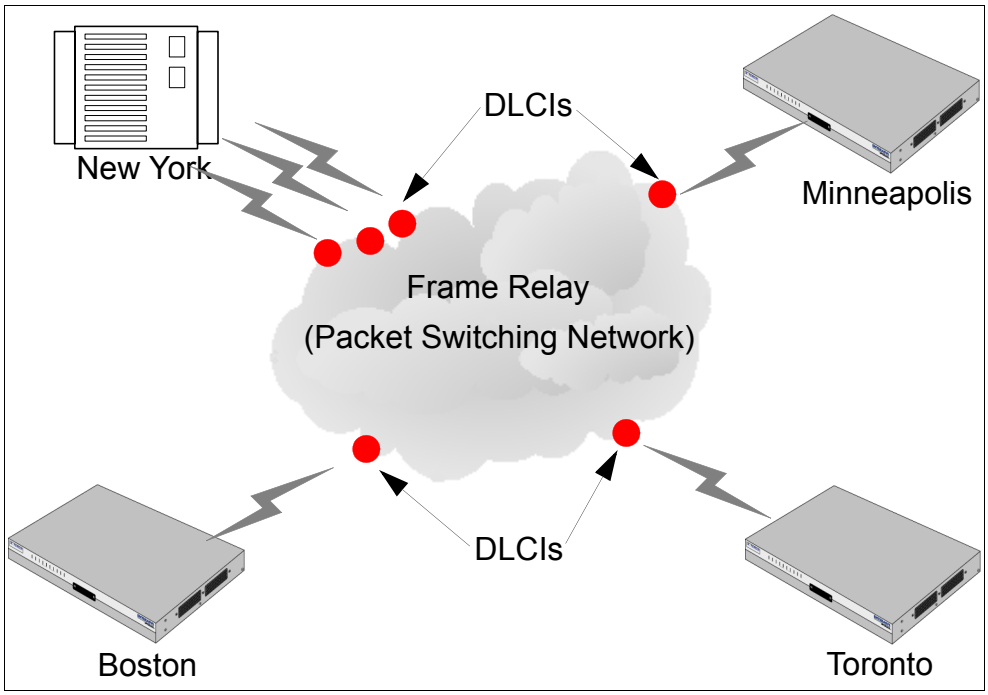
FR is based on the Virtual Circuit (VC) - a two-way, always on, software-defined data path between two ports that acts as a "private" line in the network. The XSR supports Permanent Virtual Circuits (PVCs), multiplexing several PVCs in a single FR port, which reduces the number of physical connections required to link sites. FR can be configured with multiple PVCs connecting to remote sites. See Figure 9-1 on page 9-2 for a typical network topology.

DLCIs

The Data Link Connection Identifier (DLCI) is a unique number assigned to a PVC end point, essentially, the port to which the destination network is attached, as shown in Figure 9-1. DLCIs can perform data "interleaving" from two or more devices on a single channel known as statistical multiplexing. Data entering a FR switch are processed by the DLCI in three ways: frames are checked for integrity, their associated DLCI is looked up in the DLCI table, and they are relayed to their destination through the port specified in the table. If the checks reveal errors or do not find the DLCI in the table, frames are discarded.

The **`frame-relay interface-dlci`** command maps a DLCI to a specified FR sub-interface.

Figure 9-1 Frame Relay Network Topology



From the perspective of the OSI reference model, Frame Relay is a high-performance WAN protocol suite operating at the physical and data link layers (1 and 2). Starting from a source site, variable-length packets are switched between various network segments until the destination is reached.

Devices attached to a FR WAN fall into two categories: Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE).

DTEs

A DTE is a network end station, either the ultimate source or destination of data through a FR network. A FR device can be a router, bridge, terminal or PC. For example, the XSR acts as a DTE originating or terminating device.

As a source device, a DTE encapsulates data in a FR frame and transmits. As a destination device, a DTE de-encapsulates FR data (strips the FR "header" from the packet) leaving only user IP data. The **`frame-relay intf-type dte`** command assigns the device to the port.

DCEs

A DCE is an internetwork switching device located at your service provider's premises. DCEs provide network clocking and the switches which actually transmit data across the WAN. In most cases, these are packet switches.

The connection between a DTE device and a DCE device consists of both physical- and link-layer components. The physical component defines mechanical, electrical, functional, and procedural specifications of the connection between the devices while the link-layer component defines the protocol that establishes the connection between the DTE and the DCE.

Frame Relay Features

The XSR supports the following FR features:

- The XSR acts as a DTE/DCE device in the UNI (User Network Interface) interface, supporting FR PVC connections (NNI functionality is *not* supported)
- 10-bit DLCI addressing using a 2-byte DLCI header (3- and 4-byte headers are not supported)
- Rate enforcement (CIR) with automatic rate fallback via traffic/adaptive shaping when the network is congested. Automatically restores to normal rates when congestion is removed
- Congestion control by Backward Explicit Congestion Notification (BECN). The XSR does not send packets with the BECN bit set
- Discard Eligibility (DE) bit - traffic is counted as it is received
- Three standard LMIs: ILMI (FRF1.1) ANSI Annex D, CCITT Annex A. Also supported: *Auto* LMI detect and *None.* The *Full Status Continue Report* type as defined by Annex A of FRF1.2 allowing LMI status messages to be broken into small sizes, is not supported since it is relevant only if more than 300 DLCIs are supported on one physical interface
- Multi-protocol interconnect over FR (RFC-2427). IP is supported
- Frame Relay Inverse ARP per RFC-2390
- LMI DCE support includes Asynchronous Status Messages.
- Auto and ILMI support 190 DLCIs per interface. Other LMI protocols support 300 per interface.
- Multiple logical interfaces over the same physical FR port (sub-interfaces)
- Quality of Service: standard FIFO queuing, or IP QoS on DLCIs
- Industry-standard CLI and statistics
- Maximum PDU size of 1536 bytes
- End-to-end packet fragmentation per FRF.12
- SNMP support per RFC-2115
- Traffic shaping

The XSR proscribes the following maximum configuration limits:

- 1000 FR interfaces or sub-interfaces per node
- 1000 DLCIs per node
- 30 sub-interfaces per FR interface
- 300 PVCs per FR interface for LMI ANSI, Q933A, NONE
- 190 PVCs per FR interface for LMI AUTO, ILMI
- 300 FR map-classes

Multi-Protocol Encapsulation

XSR supports encapsulation of multiple protocols - a flexible way to carry many protocols via FR. This method is useful when it is necessary to multiplex/de-multiplex across one FR connection, as described by RFC-2427, which defines a generic, end-to-end encapsulation mechanism for devices to communicate many protocols over a single port.

Address Resolution

The XSR supports dynamic resolution via Inverse ARP to map virtual circuits (DLCI) to remote protocol addresses, as defined in RFC-2390.

Dynamic Resolution Using Inverse ARP

Inverse ARP lets a network node request a next hop IP address corresponding to a given hardware address. Technically, this applies to FR nodes that may have a Data Link Connection Identifier (DLCI), the FR equivalent of a hardware address, associated with an established Permanent Virtual Circuit (PVC), but do not know the IP address of the node on the other side of the link.

Controlling Congestion in Frame Relay Networks

While FR provides dedicated, logical channels throughout the network, these channels share physical resources - links and FR switches, for example. When a DLCI is provisioned, the network assigns a Committed Information Rate (CIR), Committed burst (Bc) and Excess burst (Be) values for the virtual circuit.

Both CIR and Bc values are guaranteed under normal conditions. Excess burst bandwidth, though, is not guaranteed at all times. You can set the CIR rate on the XSR with the **`frame-relay cir`** command.

FR network design assumes that not all users will need all of their provisioned bandwidth all the time, and that any unused excess capacity can be borrowed by other customers to send bursts of data exceeding their Committed burst rate. In this environment, it is possible for multiple users to contend for the same resources at the same time causing congestion.

If congestion does occur, FR provides several reactive mechanisms, including explicit congestion notifications that inform end stations that congestion exists on the network.

One issue with reactive congestion controls is that congestion has already occurred. Although congestion is eventually cleared, frames may be lost and response times reduced. This problem can be solved if network traffic is limited to avoid congestion in the first place and that is accomplished with enforced CIR for a PVC.

CIR enforcement also prevents a PVC from hogging all the bandwidth on the access link - the connection between the access device and the FR switch. Without this feature, one VC can use all the access-link bandwidth before FR congestion techniques even start up.

Rate Enforcement (CIR) - Generic Traffic Shaping

Traffic shaping is a high level mechanism of throttling bursty output traffic to address congestion on the network, enabled by the **`frame-relay traffic-shaping`** command on the XSR. Adaptive shaping is the ability to further reduce CIR to alleviate network congestion, enabled by the **`frame-relay adaptive-shaping`** command on the XSR.

CIR is the minimum rate of service that a public FR provider guarantees for a given PVC under normal conditions. FR provides the ability to burst beyond the CIR if bandwidth is available.

You can transmit traffic at a rate exceeding the CIR using Excess Information Rate (EIR), but excess traffic might be discarded in the event of congestion. Traffic shaping prevents traffic from being sent in excess of a value such as CIR, which considerably reduces the likelihood of network congestion. Without this feature, one VC could use all the access-link bandwidth before FR congestion techniques even begin.

Several other parameters work hand-in-hand with CIR in controlling traffic flow. Committed burst (Bc) is the peak number of bits that the network attempts to deliver during a given period.

Bc differs from CIR - it is a number, not a rate. CIR is equal to the committed burst divided by time interval Tc, expressed in the formula: CIR = Bc/Tc. The **`frame-relay bc`** command sets outgoing committed burst size.

Excess burst (Be) is the maximum number of bits that you may send in excess of Bc. Sent on a best-effort basis, these bits will likely be discarded during congestion. The **`frame-relay be`** command sets outgoing excess burst size.

Another method of traffic shaping is the use of queues to limit surges that can congest a network. Data is buffered and then sent to the network in regulated amounts to ensure that traffic will fit within the promised traffic envelope for the particular connection. Traffic shaping is also known as metering, shaping, and smoothing.

Discard Eligibility (DE) Bit

The Discard Eligibility (DE) bit is one of the many fields in a frame header. A FR DTE device sets this bit to one (1) to indicate that the current frame rate is above the committed burst and that the switch may discard this packet before any other packets with the DE bit set to 0 during congested periods. When discarding DE-eligible data, by itself, is insufficient to ease severe congestion, more incoming frames are discarded without regard to the DE bit setting.

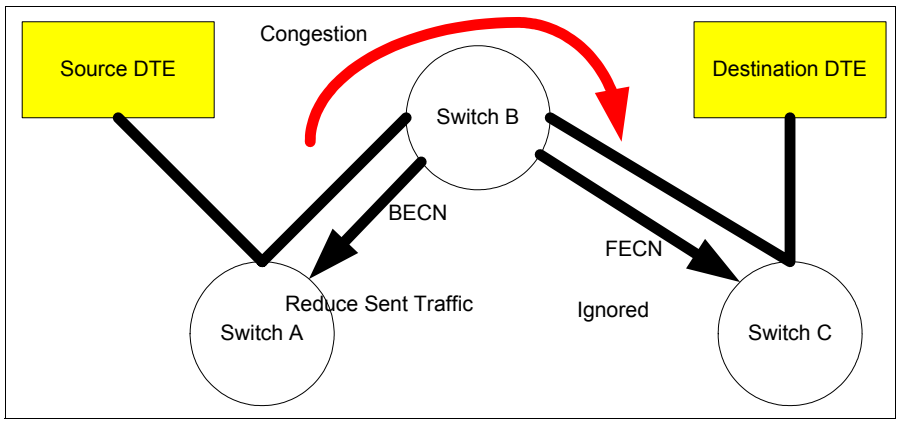
Forward Explicit Congestion Notification (FECN)

Forward Explicit Congestion Notification (FECN) sets a bit to inform the DTE device getting the frame of congestion in the path from source to destination. A DTE device receiving frames with the FECN bit set can request higher-level protocols to take flow-control action as needed. The XSR counts frames with the FECN bit set, otherwise it *does not* act on frames with the bit set.

Backward Explicit Congestion Notification (BECN)

Backward Explicit Congestion Notification (BECN) sets a bit in frames traveling the opposite direction of frames encountering a congested path, as shown in Figure 9-2. A DTE device getting frames with the BECN bit set assuredly is sending frames into a congested network. This means all data sent at the excess data rate are being tagged for discard and possibly lost. It is helpful to the DTE to proactively throttle output to help the network exit from a congested state.

Figure 9-2 Congestion Notification



Using BECN bits to control the outbound dataflow is known as *adaptive shaping*. It is disabled by default on the XSR. To activate it, you must first enable traffic shaping on the port then associate a map class with this interface, sub-interface or DLCI which has the adaptive shaping value set.

Note: BECN will not operate unless traffic shaping is enabled.

The following sample configuration shows how to activate BECN support:

```
XSR(config)#map-class frame-relay STG
XSR(config-map-class<STG>)#frame-relay cir out 64000
XSR(config-map-class<STG>)#frame-relay bc out 8000
XSR(config-map-class<STG>)#frame-relay be out 8000
XSR(config-map-class<STG>)#frame-relay adaptive-shaping
XSR(config)#interface serial 1/0
XSR(config-if<S1/0>)#no shutdown
XSR(config-if<S1/0>)#media-type V35
XSR(config-if<S1/0>)#encapsulation frame-relay
XSR(config-if<S1/0>)#frame-relay lmi-type ansi
XSR(config-if<S1/0>)#frame-relay traffic-shaping
XSR(config)#interface serial 1/0.1 multi-point
XSR(config-subif<S1/0.1>)#frame-relay interface-dlci 16
XSR(config-fr-dlci<S1/0.1-16>)#class STG
XSR(config-fr-dlci<S1/0.1-16>)#no shutdown
XSR(config-fr-dlci<S1/0.1-16>#ip address 210.16.0.1 255.255.0.0
```

Under normal circumstances, a DLCI is authorized to transmit a number of bits per an interval of time. The number of bits is composed of adding Bc and Be values (8000, 8000 = 16000 bits). The interval allowed to transmit this quantity of bits is based on the formula: *Bc/CIR (8000/64000 = 125 milliseconds*). So, under normal non-congested conditions, this DLCI can transmit up to 16000 bits every 125 milliseconds.

Note: If adaptive shaping is on and BECNs are received, the XSR becomes congested and cuts the DLCI output rate. Other DLCIs' throughput is unaffected.

Upon receiving the first BECN, the Be amount is removed from the equation. Now the DLCI can transmit 8000 bits every 125 milliseconds. If no more BECNs are received within three seconds, one-half of the Be amount is added back each 3-second interval until the Be is fully restored.

Upon receiving additional BECNs within three seconds, the CIR is reduced by 1/8th of the current CIR. Every three seconds that BECNs are received, the CIR will be reduced by an additional 1/8th of the new CIR value, until the new CIR value is one-half of the original CIR value. One-half of the original CIR is called the minimum CIR, a non-configurable parameter.

Once BECNs stop being received, the current CIR begins to recover the original CIR at a rate of 1/16th of the original CIR every 3 seconds: 1/16th facilitates a graceful, slower recovery in the hope of preventing network thrashing when all devices start recovering from congestion. After CIR is fully recovered, Be is reintroduced at a rate of 1/2 of Be every 3 seconds.

Link Management Information (LMI)

A FR UNI-DCE device communicates with an attached FR DTE device (e.g., the XSR) about the status of the PVC connections through Link Management Information protocol (LMI).

LMI monitors the status of the connection and provides the following data:

- Active/inactive interface - known as a *keep alive* or *heartbeat* signal
- The valid DLCIs defined for that interface
- The status of each DLCI (either New, Activate or Delete)

Three versions of the LMI specification are listed in Table 9-1 below:

Table 9-1 LMI Specifications

Protocol	Specification
ILMI, (OGOF)	Frame Relay Forum Implementation Agreement (IA). FRF.1 superseded by FRF.1.1
Annex D (ANSI)	ANSI T1.617
Annex A (Q933a)	ITU Q.933

The protocol defined for the LMI provides a *status enquiry* message which the XSR can send, either as a *keep alive* message to inform the network that the connection to the router is still up, or as a request for a report on the status of the PVCs on that port. The network then responds with a *status* message, either in the form of a *keep alive* response or full report on the PVCs.

An optional *status update* message lets the network unilaterally report a PVC status change. A LMI status query provides for one-way querying and one-way response only, meaning that only the XSR can send a *status inquiry* message, and only the network can respond with a *status* message. Using status inquiries in this manner renders both sides of the interface unable to provide the same commands and responses.

In contrast to the ILMI (which uses DLCI *1023*), Annex D reserves DLCI *0* for PVC status signaling. The current requirement in Annex A signaling is similar to Annex D and also uses DLCI 0. ILMI and AUTO mode can support only 190 DLCIs per interface due to Status message size limitations. Annex D and A can support up to 300 DLCIs per interface.

Note: Be sure the same version of the management protocol resides at each end of the FR link except for *Auto*.

Each version includes a slightly different use of the management protocol. The XSR implements UNI-DTE and UNI-DCE for all three LMI types as well as *auto,* which is the default option for the **`frame-relay lmi-type`** command. Auto is the fastest LMI type to discover and activate DLCIs.

Sub-interfaces

The XSR implements FR as a multi-access media in which one interface to the network - the physical link - has one or more destinations, namely, virtual connections which are grouped with their corresponding physical link. For this purpose, the XSR groups one or more PVCs under separate *sub-interfaces*, which in turn are associated with a single physical interface.

FR sub-interfaces are created with the **`interface serial <multi-point | point-to-point>`** command. The **`frame-relay interface-dlci`** command assigns a DLCI to a sub- interface and the **`class`** command assigns a map class to a DLCI on a sub-interface.

FRF.12 Fragmentation

Generally speaking, it is difficult to deliver good end-to-end quality of service for time-sensitive packets (voice and video) when operating over low speed FR lines (64 kbps or lower), especially when the link is also used to transport large packets (1500-byte FTP traffic). This is due to the fact that it takes 214 milliseconds to send a 1500-byte packet over a 56 kbps link. If a high priority voice packet happens to arrive after the FR port has started sending a large packet, the voice packet would be delayed for at least 214 mS before it can be sent over the link. This delay renders the voice quality choppy and unusable.

The FRF.12 implementation agreement aims to alleviate this problem by breaking up large packets into a series of small fragments, and allowing high priority, non-fragmented packets on the same DLCI to be sent between the small fragments that comprise a large packet. If the fragment size is 100 bytes, then the maximum delay a high priority packet can experience due to the serialization delay of a previous fragment is approximately 20 mS on the 56 kbps link. This is 10 times less than the case *without* fragmentation.

End-to-End Fragmentation

The XSR supports end-to-end fragmentation such that both end stations must participate in the fragmentation process and fragmentation must be transparent to the FR network. This feature is useful when the link between both end stations on the FR network is running at a relatively low speed.

End-to-end fragmentation is configured on a per DLCI basis. If one DLCI requires fragmentation, we recommend that all DLCIs on a given interface be configured for fragmentation. But, there are a couple of exceptions:

- For a link whose speed is fast enough to keep latency from large packets at a reasonable level
- For DLCIs known to pass only moderately- sized packets (those less than or equal to the fragment size) will not cause excessive serialization delay even when sent un-fragmented.

Enabling fragmentation on a Frame Relay connection is meant to allow data which is sensitive to latency to be transmitted with as low a delay as possible. To ensure a low delay path, QoS is required to classify the traffic so that only low latency traffic is configured on the *high* priority queue. All other traffic can then be classified appropriately on the remaining queues.

Careful configuration is mandatory since it is possible to defeat the purpose of fragmentation by sending a high priority packet which is larger than the configured fragment size.

Usually, a high priority packet will be interleaved between fragments of a larger lower priority packet. But, if the high priority packet is too large it will need to be fragmented before being transmitted. Only one packet which requires fragmenting can be transmitted at a time - multiple fragmented packets are *not* interleaved. If a low priority packet is currently being transmitted, the high priority packet will need to wait until all packets are delivered and so will suffer from higher latency.

The **`frame-relay fragment`** command sets the fragment size in the FR map class and the **`show frame-relay fragment`** command displays statistics.

User Configuration Commands

The XSR interprets all CLI commands immediately and become part of the running configuration. If a parameter in a FR map is changed, the change is reflected automatically by FR devices which reference this map. But new configuration changes are not saved into the startup configuration file

until you enter the **copy running config startup config** command to copy the running configuration into the startup configuration file within Flash.

Map-Class Configuration

The Map Class configures a common profile (characteristics) that can be applied to PVCs, eliminating the need to configure parameters on all individual PVCs. The **map-class frame-relay** command configures a FR map class.

Show Running Configuration

The **show running-configuration** command displays the running configuration on the screen.

Note: Only those parameters different than default values are displayed.

Displaying Statistics

The following **show** commands display Frame Relay statistics:

- **show frame-relay lmi** — displays global or interface LMI counters.
- **show frame-relay map** — displays DLCIs and remote nodes' IP addresses discovered by Inverse ARP.
- **show frame-relay traffic** — displays Inverse ARP traffic statistics.
- **show frame-relay pvc** — displays global or per interface, sub-interface or DLCI data.
- **show fragment** — displays fragmentation information in a summary or detailed format.
- **show map-class** — displays class information for all configured map-classes as well as the interfaces which are registered with them.

Reports and Alarms

The FR-related alarms are described in Appendix A: "Alarms/Events, System Limits, and Standard ASCII Table" on page A-1.

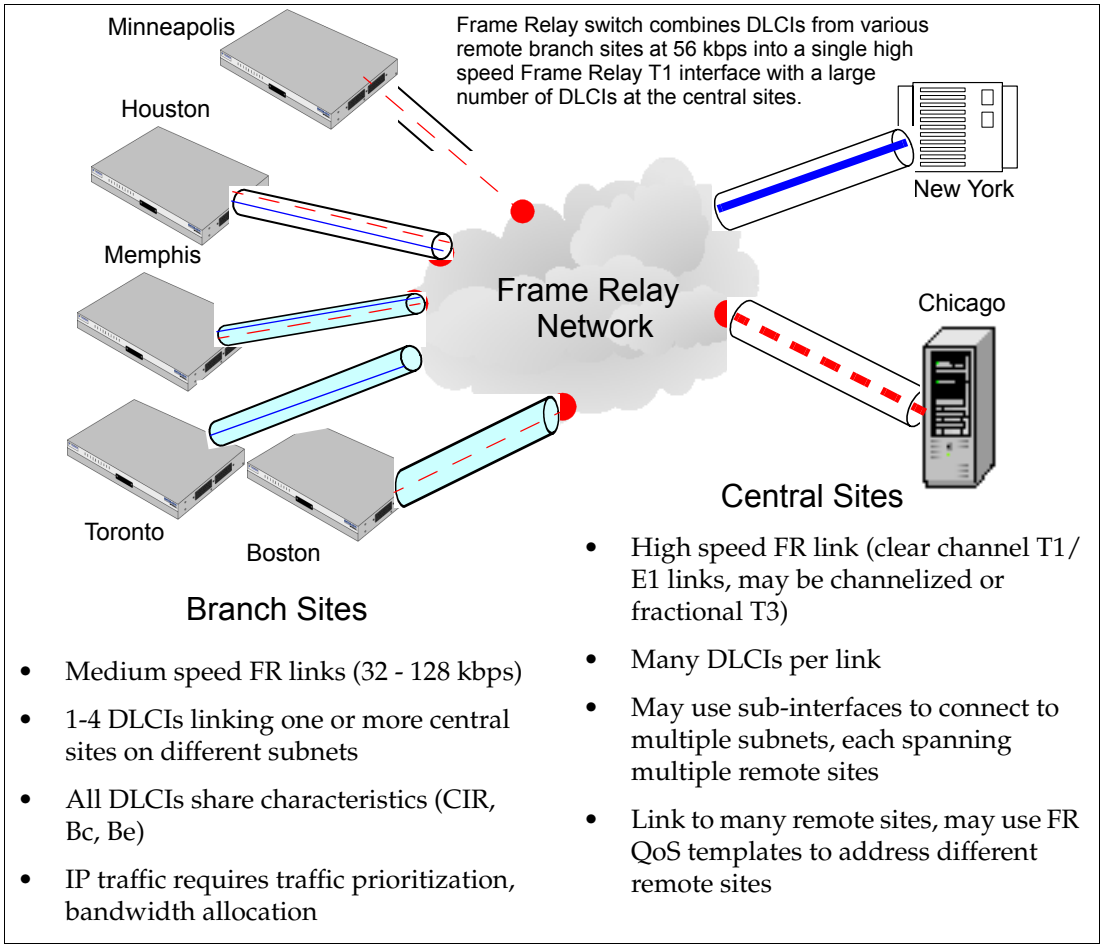
Clear Statistics

When it becomes necessary, you can strip the Inverse ARP Table and other tables of FR statistics with the **clear frame-relay inarp** and **clear frame-relay counter** commands. The **clear frame-relay inarp** command deletes particular or global FR port data and the **clear frame-relay counter** command deletes specific or global DLCI or FR port data.

Interconnecting via Frame Relay Network

The following typical application uses FR to link remote branches to the corporate network at the central sites via a FR network, as shown in Figure 9-3.

Figure 9-3 Branch/Central Frame Relay Topology

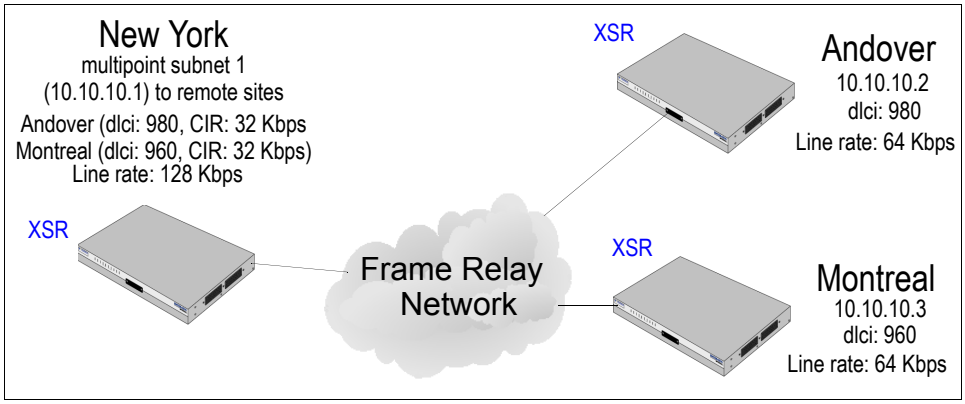


Configuring Frame Relay

Multi-point to Point-to-Point Example

The following example configures the XSR in New York to connect with XSRs in Andover and Montreal using Frame Relay, as shown in Figure 9-4.

Figure 9-4 Frame Relay Multipoint to Point-to-Point Topology



The following CLI commands enable the sample multipoint to point-to-point configuration pictured above. At the New York site, multipoint networks with a 64 Kbps-PVC are configured to Andover and Montreal. The line rate of New York is 128 Kbps and 64 Kbps at both Andover and Montreal.

Begin configuration on the New York XSR by creating the QoS class maps *Tos4*, *EF*, and *AF1* with IP precedence and DSCP classification match criteria:

```
NewYork(config)#class-map Tos4
NewYork(config-cmap<Tos4>)#match ip precedence 4
NewYork(config-cmap<Tos4>)#class-map EF
NewYork(config-cmap<EF>)#match ip dscp 46
NewYork(config-cmap<EF>)#class-map match-any AF1
NewYork(config-cmap<AF1>)#match ip dscp 10
NewYork(config-cmap<AF1>)#match ip dscp 12
NewYork(config-cmap<AF1>)#match ip dscp 14
```

Configure the QoS policy map *Voice* with scheduling and bandwidth policy criteria for the *EF*, *Tos4*, *AF1* class maps:

```
NewYork(config-cmap<AF1>)#policy-map Voice
NewYork(config-pmap<Voice>)#class EF
NewYork(config-pmap-c<EF>)#priority high 2
NewYork(config-pmap-c<EF>)#class Tos4
NewYork(config-pmap-c<Tos4>)#priority medium 48
NewYork(config-pmap-c<Tos4>)#class AF1
NewYork(config-pmap-c<AF1>)#bandwidth percent 20
```

Configure the QoS policy map *frf12* with burst, CIR and fragmentation values. Also, assign the *Voice* QoS service policy to the output of the interface (Serial 2/0) you will configure in the next section.

```
NewYork(config)#map-class frame-relay frf12
NewYork(config-map-class<frf12>)#frame-relay cir out 32000
```

```
NewYork(config-map-class<frf12>)#frame-relay bc out 4000
NewYork(config-map-class<frf12>)#frame-relay be out 5000
NewYork(config-map-class<frf12>)#frame-relay fragment 53
NewYork(config-map-class<frf12>)#service-policy out Voice
```

Configure Serial interface 2/0 with FR parameters including traffic shaping:

```
NewYork(config)#interface Serial 2/0
NewYork(config-if<S2/0>)#media-type V35
NewYork(config-if<S2/0>)#encapsulation frame-relay
NewYork(config-if<S2/0>)#frame-relay lmi-type ANSI
NewYork(config-if<S2/0>)#frame-relay traffic-shaping
NewYork(config-if<S2/0>)#frame-relay class frf12
NewYork(config-if<S2/0>)#no shutdown
```

Configure Serial sub-interface 2/0.1 for a multi-point connection with DLCIs 980 and 960:

```
NewYork(config)#interface Serial 2/0.1 multi-point
NewYork(config-subif<S2/0.1>)#ip address 10.10.10.1 255.255.255.0
NewYork(config-subif<S2/0.1>)#no shutdown
NewYork(config-subif<S2/0.1>)#frame-relay interface-dlci 980
NewYork(config-subif<S2/0.1-980>)#frame-relay interface-dlci 960
```

On the Andover XSR, create the QoS class maps similar to those on the New York XSR:

```
Andover(config)#class-map Tos4
Andover(config-cmap<Tos4>)#match ip precedence 4
Andover(config-cmap<Tos4>)#class-map EF
Andover(config-cmap<EF>)#match ip dscp 46
Andover(config-cmap<EF>)#class-map match-any AF1
Andover(config-cmap<AF1>)#match ip dscp 10
Andover(config-cmap<AF1>)#match ip dscp 12
Andover(config-cmap<AF1>)#match ip dscp 14
```

Configure the QoS policy map *Voice* with scheduling and bandwidth policy criteria for the *EF*, *Tos4*, *AF1* classes:

```
Andover(config-cmap<AF1>)#policy-map Voice
Andover(config-pmap<Voice>)#class EF
Andover(config-pmap-c<EF>)#priority high 2
Andover(config-pmap-c<EF>)#class Tos4
Andover(config-pmap-c<Tos4>)#priority medium 48
Andover(config-pmap-c<Tos4>)#class AF1
Andover(config-pmap-c<AF1>)#bandwidth percent 20
```

Configure the policy map *frf12* with criteria similar to those on the New York XSR:

```
Andover(config)#map-class frame-relay frf12
Andover(config-map-class<foo>)#frame-relay cir out 32000
Andover(config-map-class<foo>)#frame-relay bc out 4000
Andover(config-map-class<foo>)#frame-relay be out 5000
Andover(config-map-class<foo>)#frame-relay fragment 53
Andover(config-map-class<foo>)#service-policy out Voice
```

Configure Serial interface 2/0 with FR parameters including traffic shaping:

```
Andover(config)#interface Serial 2/0
Andover(config-if<S2/0>)#media-type V35
Andover(config-if<S2/0>)#encapsulation frame-relay
```

```
Andover(config-if<S2/0>)#frame-relay lmi-type ANSI
Andover(config-if<S2/0>)#frame-relay traffic-shaping
Andover(config-if<S2/0>)#frame-relay class frf12
Andover(config-if<S2/0>)#no shutdown
```

Configure Serial sub-interface 2/0.1 for a point-to-point connection with DLCI 980:

```
Andover(config)#interface Serial 2/0.1 point-to-point
Andover(config-subif<S2/0.1>)#ip address 10.10.10.2 255.255.255.0
Andover(config-subif<S2/0.1>)#no shutdown
Andover(config-subif<S2/0.1>)#frame-relay interface-dlci 980
```

On the Montreal XSR, create the QoS class maps similar to those on the New York XSR:

```
Montreal(config)#class-map Tos4
Montreal(config-cmap<Tos4>)#match ip precedence 4
Montreal(config-cmap<Tos4>)#class-map EF
Montreal(config-cmap<EF>)#match ip dscp 46
Montreal(config-cmap<EF>)#class-map match-any AF1
Montreal(config-cmap<AF1>)#match ip dscp 10
Montreal(config-cmap<AF1>)#match ip dscp 12
Montreal(config-cmap<AF1>)#match ip dscp 14
```

Configure the QoS policy map *Voice* with scheduling and bandwidth policy criteria for the *EF*, *Tos4*, *AF1* classes:

```
Montreal(config-cmap<AF1>)#policy-map Voice
Montreal(config-pmap<Voice>)#class EF
Montreal(config-pmap-c<EF>)#priority high 2
Montreal(config-pmap-c<EF>)#class Tos4
Montreal(config-pmap-c<Tos4>)#priority medium 48
Montreal(config-pmap-c<Tos4>)#class AF1
Montreal(config-pmap-c<AF1>)# bandwidth percent 20
```

Configure the policy map *frf12* with criteria similar to those on the New York XSR:

```
Montreal(config)#map-class frame-relay frf12
Montreal(config-map-class<foo>)#frame-relay cir out 32000
Montreal(config-map-class<foo>)#frame-relay bc out 4000
Montreal(config-map-class<foo>)#frame-relay be out 5000
Montreal(config-map-class<foo>)#frame-relay fragment 53
Montreal(config-map-class<foo>)#service-policy out Voice
Montreal(config-map-class<foo>)#exit
```

Configure Serial interface 2/0 with FR parameters including traffic shaping:

```
Montreal(config-if<S2/0>)#media-type V35
Montreal(config-if<S2/0>)#encapsulation frame-relay
Montreal(config-if<S2/0>)#frame-relay lmi-type ANSI
Montreal(config-if<S2/0>)#frame-relay traffic-shaping
Montreal(config-if<S2/0>)#frame-relay class frf12
Montreal(config-if<S2/0>)#no shutdown
```

Configure Serial sub-interface 2/0.1 for a point-to-point connection with DLCI 960:

```
Montreal(config)#interface Serial 2/0.1 point-to-point
Montreal(config-subif<S2/0.1>)#ip address 10.10.10.3 255.255.255.0
Montreal(config-subif<S2/0.1>)#no shutdown
Montreal(config-subif<S2/0.1>)#frame-relay interface-dlci 960
```

10

Configuring Dialer Services

This chapter details information about the XSR's suite of dialer functionality:

- Dial
- Ethernet Failover
- Backup Dialer
- Dial on Demand (DoD)
- Bandwidth on Demand (BoD)
- Multilink PPP (MLPPP)
- Dialer Interface Spoofing
- Dialer Watch

Overview of Dial Services

Dial Services provide network connections across the Public Switched Telephone Network (PSTN). Networks are typically interconnected using dedicated lines for Wide-Area Network (WAN) connections. Dial Services can use modems, Integrated Service Data Network (ISDN) terminal adapters (TAs), or integrated ISDN capabilities to establish low-volume, periodic network connections over public circuit-switched networks.

Dial Services are a cost-saving alternative to a leased line connection between two peers and they can be implemented for different types of media for both inbound and outbound connections.

Dial Services Features

The XSR supports the following dialer features:

- Asynchronous serial service through an external modem
- Synchronous serial
- Addressing using numbered or unnumbered interfaces
- Outbound connections
- Time of day feature
- PPP encapsulation
- CHAP, MS-CHAP and PAP authentication and security
- Callback

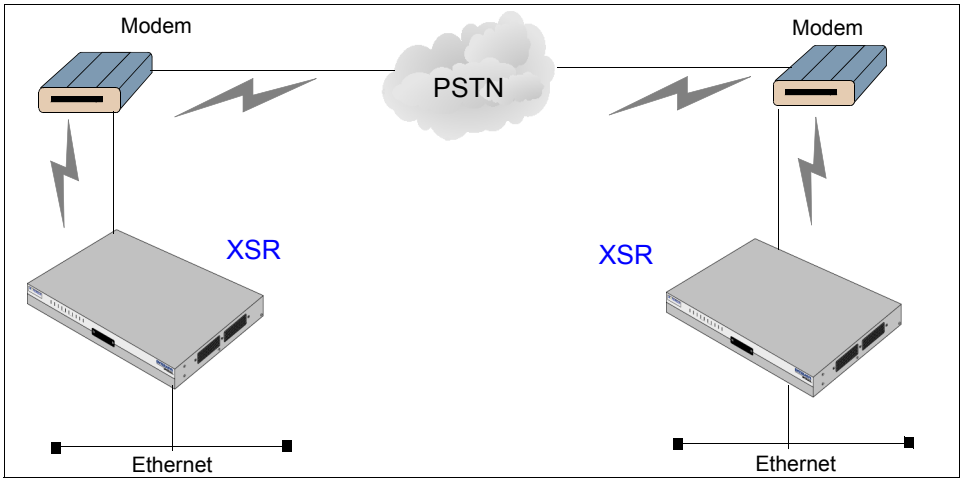
Asynchronous and Synchronous Support

Synchronous and asynchronous interfaces can be configured for dialed connections to one or more destination networks. When requested, the
XSR uses dialing commands to send the phone number of the destination network to a modem. The modem then dials the destination modem and establishes a connection. Refer to Figure 10-1.

Calls can be placed using the following methods:

- AT commands on asynchronous ports
- V.25bis over synchronous interfaces
- DTR dialing for synchronous interfaces

Figure 10-1 Typical Dial Services Interconnection



AT Commands on Asynchronous Ports

On asynchronous ports, AT commands are used to establish and clear the call. Refer to your modem documentation for a list of supported commands and options. The modem should be configured to drive Data Carrier Detect and Clear To Send CCITT V.24 signals and accept input of the Data Terminal Ready signal set by the XSR.

V.25bis over Synchronous Interfaces

Dial services also support connections from the synchronous serial interface to any modem that supports V.25bis. V.25bis supports two modes of establishing or receiving calls: direct call and addressed call. Dial services support connections using the addressed call mode and synchronous, bit-oriented operation. The addressed call mode allows control signals and commands to be sent over the modem interface to set up and terminate calls.

Devices used for dialing out must support certain hardware signals in addition to V.25bis. When the XSR drops DTR, the device must disconnect any calls that are currently connected. When the device connects to the remote end, Data Carrier Detect (DCD) must be automatically asserted. For many V.25bis devices, raised DCD requires a special cable to crossover DCD and Data Set Ready (DSR) signals.

Table 10-1 lists V.25bis options. By default, the synchronous port will use V25bis. The functions of these options are nation-specific, and they may have different implementations. Refer to your modem documentation for a list of supported commands and options.

Table 10-1 ITU-T V.25bis Options

Option	Description
:	Wait tone
<	Pause
=	Separator 3 - national use
>	Separator 4 - national use
P	Dialing to be continued in pulse mode - optional parameter
T	Dialing to be continued in DTMF mode - optional parameter
&	Flash - optional parameter

DTR Dialing for Synchronous Interfaces

Dialer interfaces also support connections from synchronous serial lines through non-V.25bis modems. Routers connected by non-V.25bis modems use data terminal ready (DTR) signaling only, which can be configured in the dialer interface by issuing the **`dialer dtr`** command in Interface mode. When using **`dialer dtr`**, the dial string is stored in the external device and need not be passed to it.

Time of Day feature

A time of day feature can be configured when you use a dialer interface as a dialed backup line for a primary leased line. When configuring the dialed backup line on the primary interface you can issue the **`time-range`** command to connect and disconnect the dial line during the day regardless of traffic on the line or whether the primary line is still down.

Typical Use for Dial Services

Dial services provide WAN connectivity on an economical, as-needed basis, either as a primary link or as backup for a non-dial serial link. Employing dial backup involves setting up a secondary serial interface as a backup to a primary serial interface. Dial services are employed solely for dial backup purposes, as of this release.

Ethernet Backup

Failover support is available on FastEthernet/GigabitEthernet interfaces or sub-interfaces where it is especially beneficial for PPPoE (DSL) redundancy. The **`backup interface dialer`** command turns failover "on" while the **`backup time-range`** and **`backup delay`** commands configure intervals to keep the port up or delay bringing it up. See "Configuration for Ethernet Failover" on page 10-40 for an example.

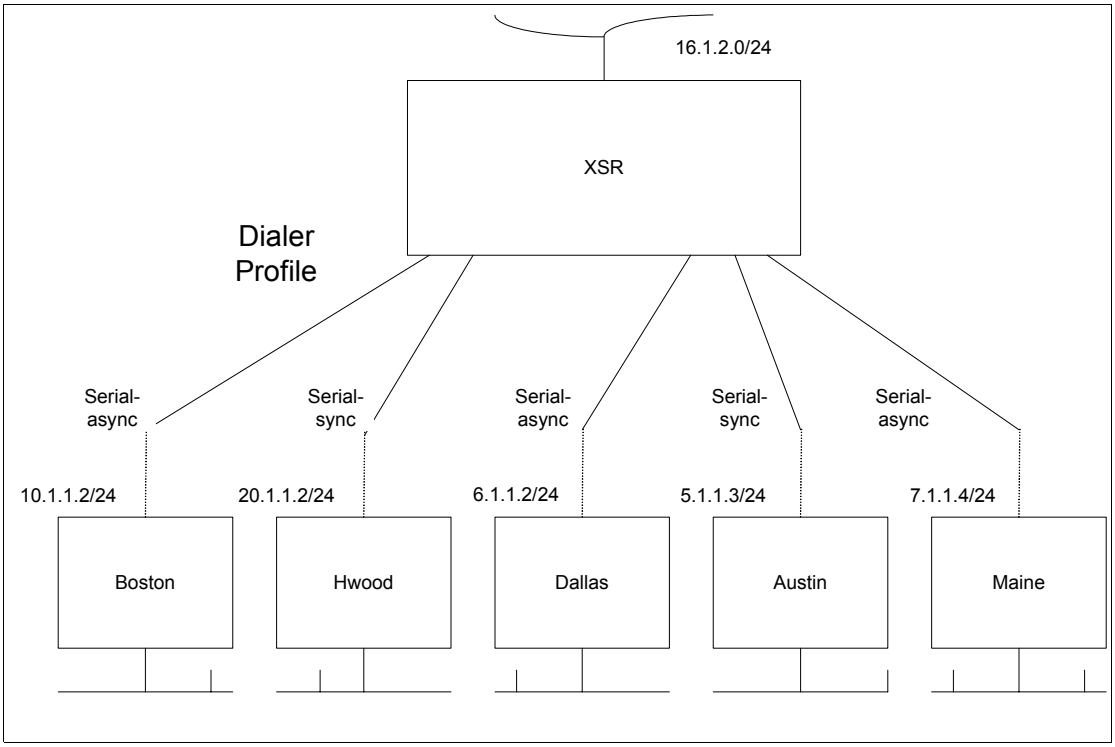
Implementing Dial Services

Dial services are provided by *dialer interfaces*, which are defined as any XSR interface capable of placing or receiving a call. You can implement Dial Services by creating a *dialer profile*.

Refer to Figure 10-2 for a network perspective and Figure 10-3 for a logical view of Dial Services.

Figure 10-2 illustrates a sample Dialer Profile which defines interface dialers in five corporate locations served by the XSR.

Figure 10-2 - Dial Services - Network View



Dialer Profiles

Dialer profiles are comprised of virtual and physical interfaces which can be bound together dynamically on a per-call basis. Dialer profiles can also be configured as physical interfaces separate from the virtual configuration required to make a connection.

This flexibility permits different dialer profiles to share XSR Serial interfaces. Dialer profiles are efficient when physical resources number less than users because a pool of resources can draw on the resources in the pool based on typical use. Be aware that all calls going to or from the same destination subnetwork use the same dialer profile.

A dialer profile consists of the following elements:

- *Dialer interface* is a virtual WAN interface you can configure with data that defines communications with destination sub-networks. The dialer interface is not constantly connected to a remote device, but dials the remote device whenever a connection is needed—on-demand. To dial up at the appropriate time requires configuring a dialer profile. It is configured with the **`interface dialer`** command. The dialer interface is spoofed by default

to support point-to-point or point-to-multi-point connections and can be non-spoofed for backup purposes. Refer to "Dialer Interface Spoofing" on page 10-18 for more information.

- Dialer *map class* defines all line characteristics of calls to the destination including the interval to wait for a dial signal. It is specified with the **`map class dialer`** command.
- *IP address* identifies the local side of the connection. It is configured with the **`ip address`** command.
- *Dialer strings* are phone numbers used to reach a destination. They are set with the **`dialer string`** command.
- *Dialer pool* is a virtual group of physical interfaces used to reach a destination. Interfaces in a dialer pool are weighted by *priority*. It is configured with the **`dialer pool`** command.

Dialer Interface

A dialer interface, which is a group of settings used by the XSR to connect to a remote network, can include multiple dial strings. Each dial string, in turn, can be associated with its own map class which defines all the characteristics for any call to the specified dial string. Refer to dialer profiles of interface dialer 0 which are illustrated in Figure 10-5 on page 10-9 and Figure 10-6 on page 10-10.

Dialer Strings

Setting dialer strings is straightforward but their configuration is very flexible. You can specify multiple dialer strings for the same dialer interface and each dialer string can be associated with a different dialer map class.

Dialer Pool

Each dialer interface uses one group of physical interfaces called a dialer pool. The physical interfaces in a dialer pool are called into use based on a priority value for selection by the XSR. Again, Serial interfaces can belong to multiple dialer pools, allowing a small number of resources to service a large number of users. The disadvantage of this method is that all resources may be in use when a user tries to access them.

Addressing Dialer Resources

There are two ways of setting up addressing on dialer resources, as follows.

- *Applying a Subnet to the Dialer Cloud* —Each site linked to the dialer cloud receives a unique node address on a shared subnet for use on its dialer interface. This method is similar to numbering a LAN or multipoint WAN and simplifies the addressing scheme and creating static routes.
- *Using Unnumbered Interfaces* —Similar to using unnumbered addressing on leased line point-to-point interfaces, the address of another interface on the XSR is borrowed for use on the dialer interface. Unnumbered addressing takes advantage of the fact that there are only two devices on the point-to-point link.

The routing table points to an interface (the dialer interface) and a next-hop address. When building static routes for unnumbered interfaces the XSR must be configured with the interface that finds the next-hop out.

Configuring Encapsulation

When a clear data link is established between two peers, traffic must be encapsulated and framed for transport across the Dialer media.

PPP is the encapsulation method of choice for Dialer Services because it supports multiple protocols and is used for synchronous or asynchronous connections. Also, PPP performs address negotiation and authentication and is interoperable with different vendors.

ISDN Callback

ISDN callback functionality, also known as dial-back, is a Dial on Demand application to handle ISDN call charge billing. The benefit of this feature is, if a caller contacts the XSR, the router will try to call back a pre-configured number, and in the process reverse the associated charge. A maximum of 32 caller numbers can be set per Dialer port.

ISDN callback is supported for PPP or Multilink PPP traffic and can be applied in a backup scenario if the retry number is set to 1.

Configured with the **`dialer caller`** *<number>* **`callback`** command, the functionality employs caller ID screening with ISDN callback to accept calls from a specified phone number. The XSR matches phone numbers starting with the last digit.

Typically the ISDN switch does not provide the complete calling number, only the local number (four to seven of the least significant digits).

Note: If the ISDN switch does not provide the calling number, callback will fail.

Callback can be configured in point-to-point or point-to-multipoint applications with one or multiple neighbors. A neighbor in this context is considered one hop away from the XSR.

Refer to "Configuring ISDN Callback" on page 10-12 for configuration examples.

Figure 10-3 on page 10-7 illustrates how Interface Dialers interact with Map Classes, Dialer Pools, Serial interfaces and three corporate sites served by the XSR. The squares with darkened backgrounds are Dialer Profiles. Note how Serial interfaces 0 - 4 and Boston and Hollywood are served by two Dialer Profiles.

Figure 10-3 Logical View of Dialer Profiles

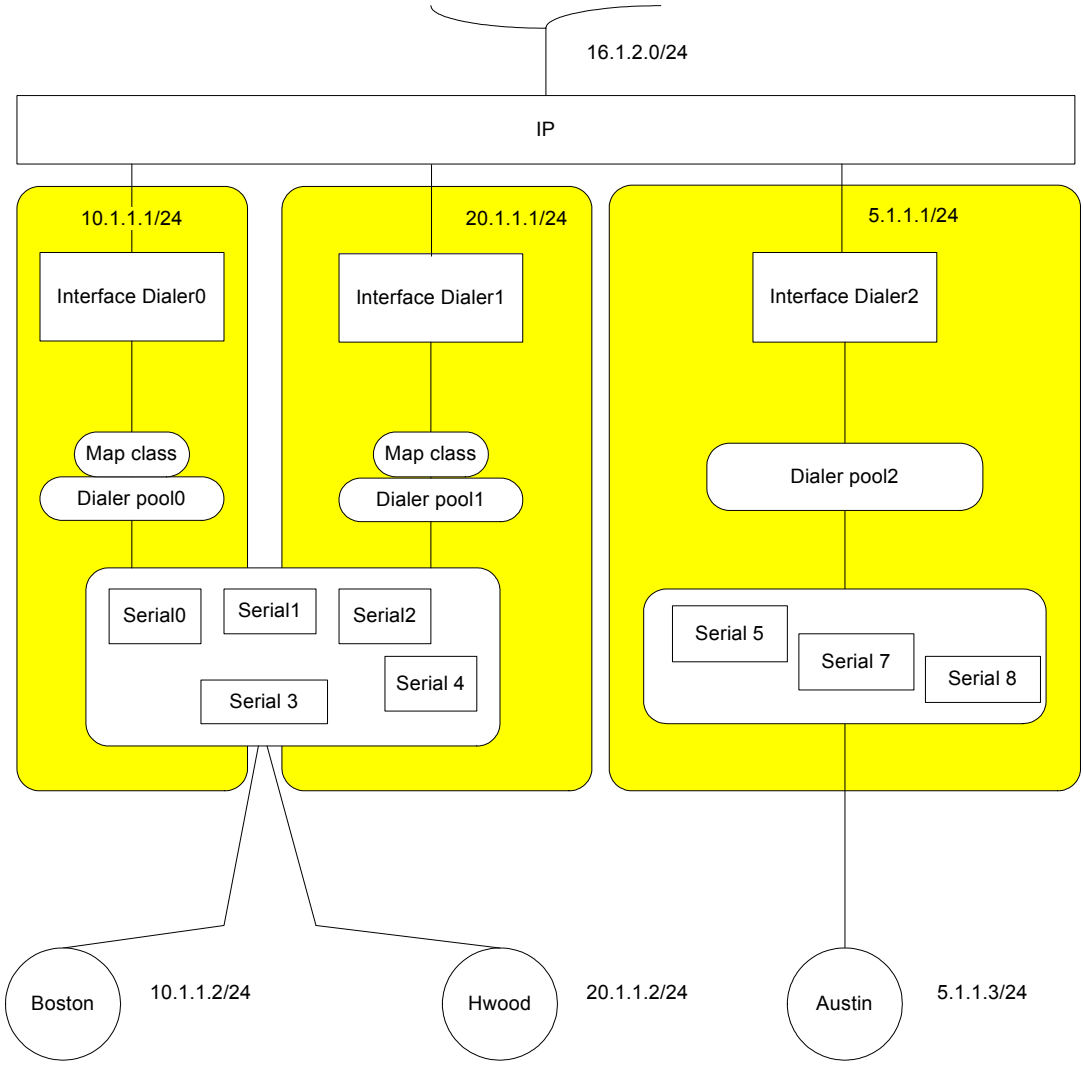
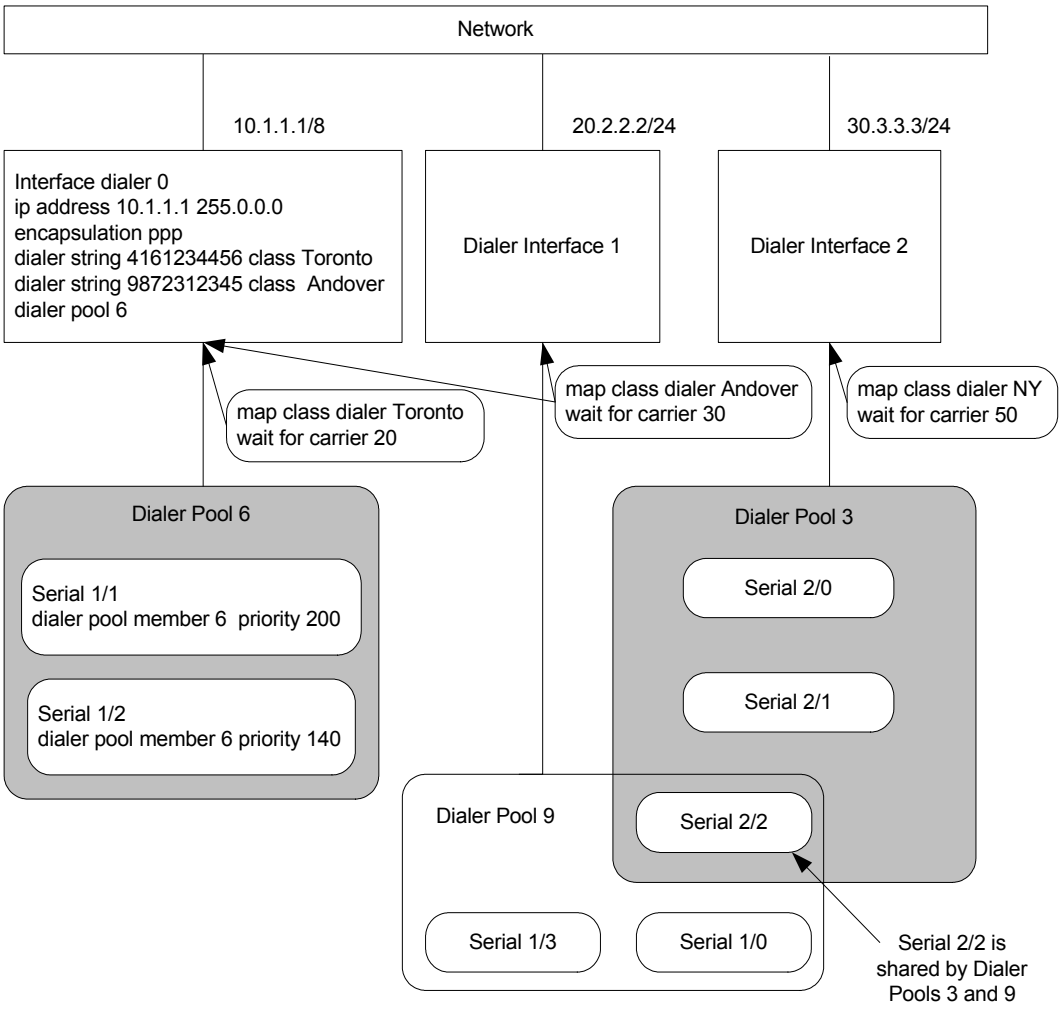


Figure 10-4 on page 10-8 illustrates three Dialer Interfaces with three associated Dialer Pools. Dialer Pool 6 supports two Serial interfaces of different priority "weighting". Dialer Pools 3 and 9 support three Serial interfaces with one interface – Serial 2/2 – shared between them.

Figure 10-4 Sample Dialer Topology



As illustrated in Figure 10-5 on page 10-9 and Figure 10-6 on page 10-10, Toronto and Andover Dialer Profiles share similar parameters except phone numbers and values specifying the interval to wait for a dial signal.

Figure 10-5 Dialer Profile of Destination (416) 123-4456

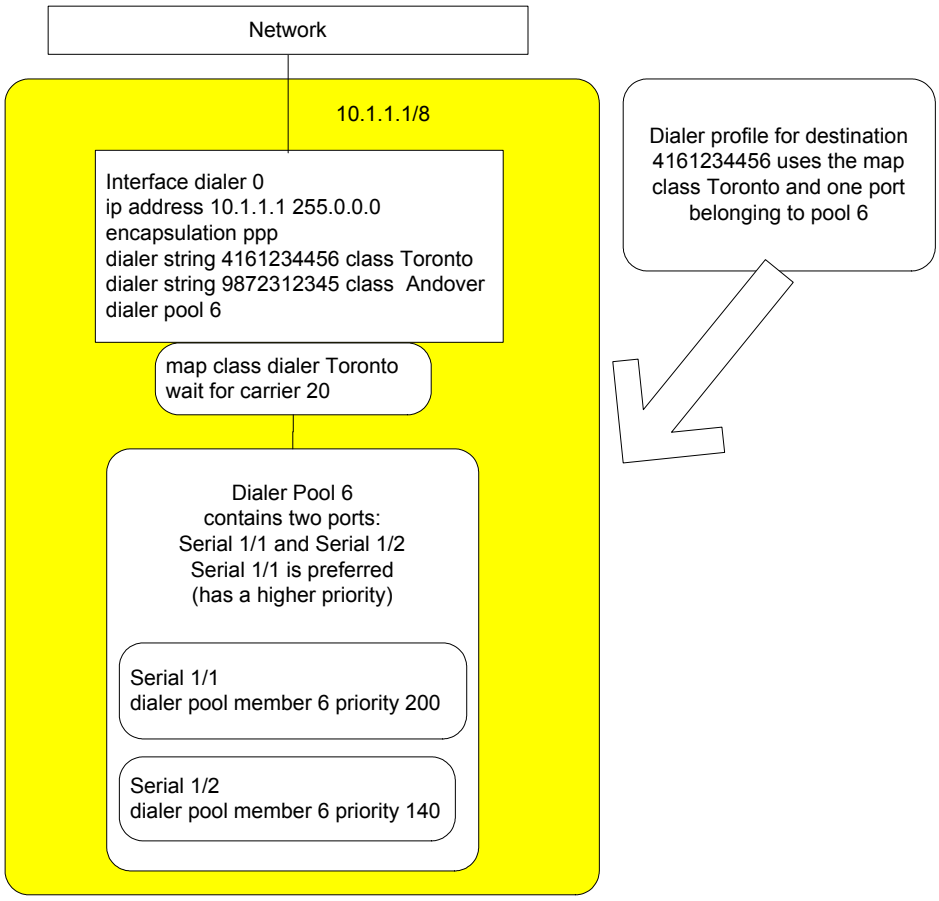
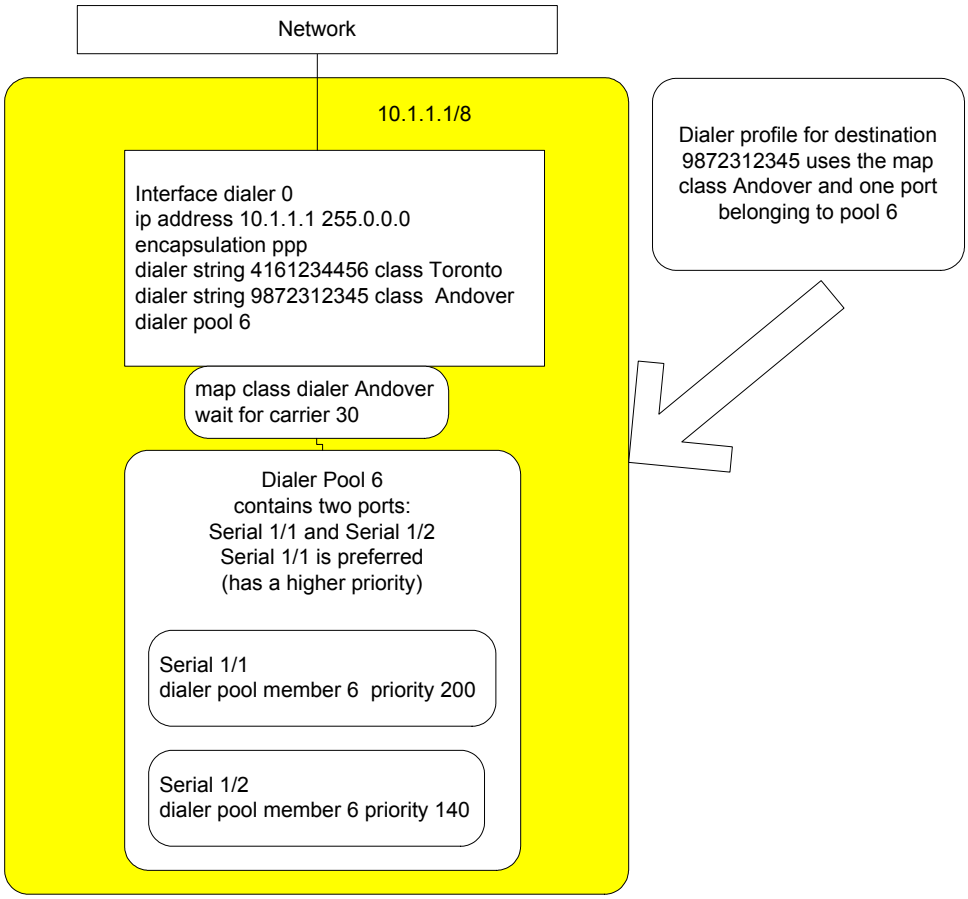


Figure 10-6 Dialer Profile of Destination (987) 231-2345



Configuring the Dialer Interface

The following tasks need to be performed to configure a dialer profile:

- Create and configure the dialer interface
- Configure a map class (optional but distinguishes dialer profiles)
- Configure a physical interface for the dialer interface

Creating and Configuring the Dialer Interface

1. Enter **interface dialer** *number* to create the dialer interface.

   The number range is 0 to 255.

2. Enter **encapsulation ppp** to enable PPP encapsulation.
3. Enter **dialer pool** *number* to specify the dialer pool.

   The number range is 0 to 255.

4. Enter **dialer string** <*dialstring*> **class** <*classname*> to specify the remote destination string to be used.

   The string is normally a 10-digit telephone number.

Configuring the Map Class

1. Enter **map-class dialer** *classname* to create a map-class identifier.

   This value must match the *classname* value you specified in the **`dialer string`** command.

2. Enter **dialer wait-for-carrier-time** *seconds* to set the interval the local modem waits to answer the call.

Configuring the Physical Interface for the Dialer Interface

1. Enter **interface serial** *card/port* to specify the interface.
2. Enter **encapsulation ppp** to set PPP encapsulation.
3. Enter **dialer pool-member** *number* **priority <priority>** to assign the interface as a member of the pool that the dialer interface will use.

   Priority is an optional value you can set to prioritize this pool-member in the pool ranging from 0 - 255. The *number* range is 0 - 255.

Sample Dialer Configuration

The CLI commands listed below are those used to configure *dialer interface 0* in Figure 10-4 on page 10-8.

Configure interface dialer 0 with two dial strings and map classes for each:

```
XSR(config)#interface dialer 0
XSR(config-if<D0>)#ip address 10.1.1.1 255.0.0.0
XSR(config-if<D0>)#encapsulation ppp
XSR(config-if<D0>)#dialer pool 6
XSR(config-if<D0>)#dialer string 4161234456 class toronto
XSR(config-if<D0>)#dialer string 9872312345 class andover
XSR(config-if<D0>)#no shutdown
```

Configure a map-class named *Toronto* with a 20-second wait for the dial tone:

```
XSR(config)#map class dialer toronto
XSR(config-map-class)#dialer wait-for-carrier-time 20
```

Configure a map-class named *Andover* with a 30-second wait for the daily tone:

```
XSR(config)#map class dialer andover
XSR(config-map-class)#dialer wait-for-carrier-time 30
```

Configure a backup link for dial purposes with priority 200:

```
XSR(config)#interface serial 1/1
XSR(config-if<S1/1>)#dialer pool 6 priority 200
XSR(config-if<S1/1>)#no shutdown
```

Configure a backup link for dial purposes with priority 140:

```
XSR(config)#interface serial 1/2
XSR(config-if<S1/2>)#dialer pool 6 priority 140
XSR(config-if<S1/2>)#no shutdown
```

Configuring ISDN Callback

The following CLI commands configure point-to-point and point-to-multipoint applications with single or multiple neighbors.

Point-to-Point with Matched Calling/Called Numbers

The following commands configure the *called* XSR with matched calling and called phone numbers:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer caller 921 callback
XSR(config-if<D1>)#dialer string 6032217921
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<D1>)#no shutdown
```

Point-to-Point with Different Calling/Called Numbers

The following commands configure the *called* XSR with different calling and called phone numbers:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer caller 921 callback
XSR(config-if<D1>)#dialer string 6783234451
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<D1>)#no shutdown
```

Point-to-Multipoint with One Neighbor

The following commands configure the *called* XSR with a callback number that may or may not differ from the dial out number. Note that a *dialer map* must be added to specify the particular number to be accepted.

```
XSR(config)#interface dialer1
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer caller 921 callback
XSR(config-if<D1>)#dialer idle-timer 0
XSR(config-if<D1>)#dialer map ip 10.10.10.2 9053617921
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<D1>)#no shutdown
```

Point-to-Multipoint with Multiple Neighbors

The following commands configure the *called* XSR with a callback number that *must* match the dial out number. The first number specified, *9053617921*, will be used for callback.

```
XSR(config)#interface dialer1
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer caller 921 callback
```

```
XSR(config-if<D1>)#dialer idle-timer 0
XSR(config-if<D1>)#dialer map ip 10.10.10.2 9053617921
XSR(config-if<D1>)#dialer map ip 10.10.10.3 9053617363
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<D1>)#no shutdown
```

Overview of Dial Backup

The dialed backup feature provides a backup link over a dial line. The backup link is brought up when failure occurs in a primary link, and is brought down when the primary link is restored.

Dial Backup Features

- User controllable delay when the link is activated for backup, and when the link is deactivated, that is, brought down.
- Dial backup is triggered when the XSR detects a primary IP circuit failure and backup is triggered to end when the circuit comes up. The secondary line is generated when an entry in routing table is lost.
- PPP and Frame Relay encapsulation. For Frame-Relay encapsulation the Dialer interface *must* be associated with a dialer sub-interface which is configured with a Frame Relay DLCI and IP address, while the parent Dialer interface carries the encapsulation information and call parameters (dial pool, dial string, and dial class). Refer to "Configuration for Frame Relay Encapsulation" on page 10-41 for an example.

Note: Dial backup may not be activated if the XSR's link at local site is up and a remote site's link is down.

Keep in mind the following when configuring backup:

- Use backup on primary interfaces that have an IP address configured *only;* that is, the **`backup`** command must be entered at the configuration level where an IP address is specified. For example, if you configure a Serial interface and sub-interface, be sure to specify backup at the sub-interface configuration mode, not at Serial interface mode.

Sequence of Backup Events

The following sequence of events occurs when a primary link fails and a backup line fails:

1. A Primary Link fails.
2. A link failure is detected. This link is configured for backup, and is monitored.
3. The Backup function is notified about link failure.
4. With the interface down, all routes reachable through that interface are removed from the routing table.
5. Backup function invokes the dialer to activate the configured (dial) backup interface.

   Activating the backup link can be delayed, if configured as such.
6. Backup link is up.
7. Backup link is activated.

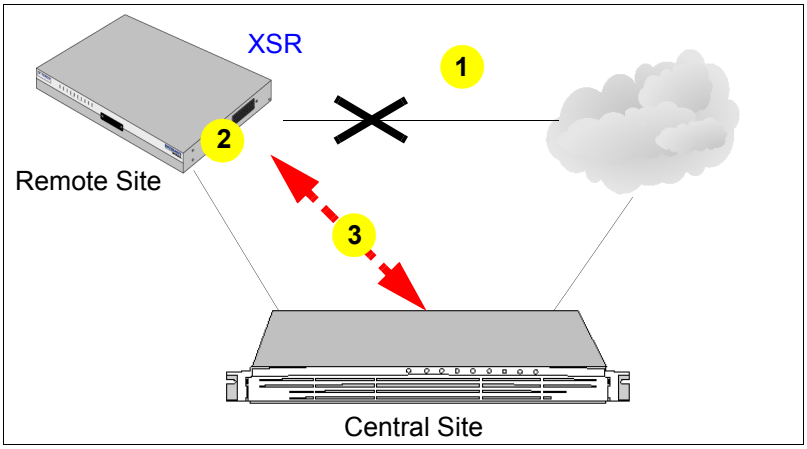
8. Backup link is up, triggering the next action.
9. Static Backup route configured - the routing process searches its configured Static Routing entries and installs the routes that can be reached through the backup interface.
10. Dynamic route - the routing protocol (RIP) learns of new available routes through the backup (dialer) interface and adds them to the IP Routing and Forwarding Table.
11. Data starts passing over the backup link.

    When the primary link is re-established the backup function will notify the Dialer to bring down the dialer interface (bringing the dialed line down).

Link Failure Backup Example

Figure 10-7 illustrates a local link failure and the dial backup process.

Figure 10-7 Backup Link Failure Example



Configuring a Dialed Backup Line

The following tasks must be performed to configure a dialed backup line:

- Configure the dialer interface
- Configure a physical interface to function as backup
- Configure primary interfaces to use a backup interface

Configuring the Dialer Interface

Perform the following steps to configure the dialer interface:

1. Enter **interface dialer** *number* to create the dialer interface.
2. Enter **encapsulation ppp** to enable PPP encapsulation.
3. Enter **dialer pool** *number* to specify the dialer pool.

Configuring the Physical Interface for the Dialer Interface

Perform the following steps to set up the physical port for the dialer interface:

1. Enter **interface serial** *card / port* to specify the interface.
2. Enter **encapsulation ppp** to set PPP encapsulation.
3. Enter **dialer pool-member** *pool-number* **priority** *priority* to assign the interface as a member of the pool that the dialer interface will use.

   Priority is an optional value you can configure to prioritize this pool-member within the pool.

Configuring Interface as the Backup Dialer Interface

Perform the following steps to configure the port for the dialer backup interface:

1. Enter **interface serial** *card/port* to specify the interface to back up.
2. Enter **ip address** *ip-address mask* to specify the IP address and mask of the interface.
3. Enter **backup interface dialer** *number* as the backup interface.
4. Enter **backup delay** *enable-delay disable-delay* to set the interval between the physical interface going down and the backup being enabled, and between the physical interface coming back up and the backup being disabled.
5. Enter **backup time-range** *start-time end-time* to set the time of day the backup interface should be enabled and disabled.

The CLI commands shown below are those used to configure the example shown in Figure 10-7 on page 10-14.

Create interface dialer 1 to use dialer pool 6:

```
XSR(config)#interface dialer1
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer pool 6
XSR(config-if<D1>)#no shutdown
```

Configure backup serial port for dialing purposes:

```
XSR(config)#interface serial 1/0
XSR(config-if<S1/0)#dialer pool-member 6
XSR(config-if<S1/0)#no shutdown
```

Configure primary serial port to have interface dialer1 as its backup interface:

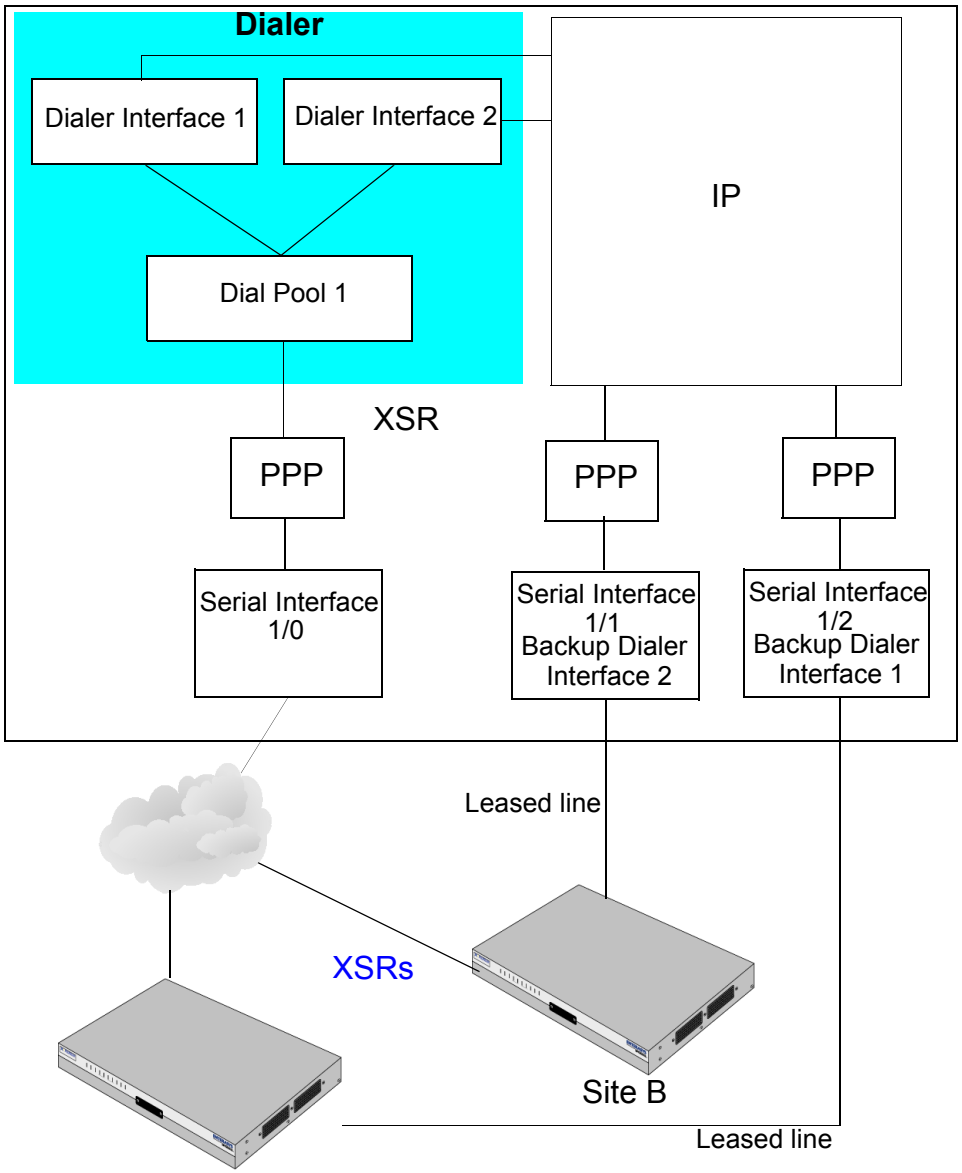
```
XSR(config)#interface serial 1/1
XSR(config-if<S1/1)#backup interface dialer1
XSR(config-if<S1/1)#backup delay 5 10
XSR(config-if<S1/1)#backup time-range 10:00 22:55
XSR(config-if<S1/1)#no shutdown
```

The **`backup time-range`** command specifies the time the backup dial line should be up. In the above example the parameters are 10:00 and 22:55, meaning that at 10:00 the backup line should be activated and at 22:55 the backup line should be deactivated. Enabling and disabling the backup interface takes place regardless of the traffic on the link when using the **`backup time-range`** command.

Sample Configuration

Figure 10-8 on page 10-16 shows an example of two dialer interfaces used to back up two separate serial lines using only one dial out line (*serial interface 1*).

Figure 10-8 Backup Dial Example



The CLI commands shown below are those used to configure the example shown in Figure 10-8:

Configure interface dialer 1 to use dial pool 5:

```
XSR(config)#interface dialer1
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer pool 5
XSR(config-if<D1>)#no shutdown
```

Configure interface dialer 2 to use dial pool 5:

```
XSR(config)#interface dialer2
```

```
XSR(config-if<D2>)#encapsulation ppp
XSR(config-if<D2>)#dialer pool 5
XSR(config-if<D2>)#no shutdown
```

Configure backup serial port for dial purposes to belong to dial pool 5:

```
XSR(config)#interface serial 1/0
XSR(config-if<S1/0>)#dialer pool-member 5
XSR(config-if<S1/0>)#no shutdown
```

Configure primary serial port to use dialer 1 as its backup interface:

```
XSR(config)#interface serial 1/1
XSR(config-if<S1/1>)#backup interface dialer1
XSR(config-if<S1/1>)#backup delay 110
XSR(config-if<S1/1>)#no shutdown
```

Configure primary serial port to use dialer 2 as its backup interface:

```
XSR(config)#interface serial 1/2
XSR(config-if<S1/2>)#backup interface dialer2
XSR(config-if<S1/2>)#backup delay 1 10
XSR(config-if<S1/2>)#no shutdown
```

Overview of Dial on Demand/Bandwidth on Demand

The XSR's Dial on Demand/Bandwidth on Demand applications provide high-speed, available-when-needed dial services over point-to-point or multipoint PPP ISDN connections. Different network topologies can be configured for different applications - mainly under Dialer Interface configuration mode - including the following:

- Dial on Demand
  - PPP Point to Multipoint
  - PPP Multi to Multipoint
  - MLPPP Point to Multipoint
  - MLPPP Multi to Multipoint
  - Incoming Call Mapping
- Switched PPP Multilink
  - Bandwidth on Demand
- Backup
  - Backup using ISDN
  - Backup with MLPPP

The caveats below apply to the XSR's support of switched multilink connections:

- They use the dialer, they are set up in Dialer interface mode and must include an ISDN interface or associated modem.
- Configuring switched connections on a Serial line is unnecessary, the process is performed automatically.
- Leased-line connections are supported and must be configured in Multilink interface mode.
- Support on FastEthernet/GigabitEthernet ports is not available.

For more information on ISDN fundamentals, refer "Configuring Integrated Services Digital Network" on page 1 and the *XSR CLI Reference Guide.*

Note: Optional commands shown in sample configurations are preceded by an exclamation point.

Dialer Interface Spoofing

Spoofing on a dialer interface is defined as the line "pretending" to be up when it is not. That is, the line is physically disconnected but the route entry is maintained in the routing table so that when a call is initiated, it is processed promptly, preserving the on-demand nature of the line.

The XSR's dialer interface supports three modes of operation:

- *Non-spoofed* - the dialer interface is *down* as long as there is no active dialup connection.
- *Spoofed point-to-point* - the dialer interface is *always up* and visible in the node's routing table.
- *Spoofed point-to-multipoint* - the dialer interface is *up* and can be directly connected to *multiple* neighbors.

You set the dialer interface mode when the interface is first created. The mode is configured with the following commands:

- **`interface dialer number`** — This is the default, *spoofed* point-to-point interface mode of operation used for *backup* and *dial-on-demand* purposes.
- **`interface dialer number multi-point`** — In spoofed point-to- multipoint mode, this option is used for *on-demand* applications.

Note: The dialer interface *cannot* be used for on-demand applications while operating in non-spoofed mode.

Additionally, the **`dialer map ip`** command is available in spoofed multi-point mode *only* and, configured as such, the dialer interface IP address cannot be negotiated.

Dialer Watch

The XSR's Dialer Watch feature backs up each route in the routing table. Backed up routing table entries can be:

- Local routes (owned by one of the XSR's physical interfaces)
- Static routes
- RIP learned routes
- OSPF learned routes

Routes requiring backup are configured with the **`dialer watch-list`** command as a collection of entries. Watch lists are identified by the watch-list number – a unique number for one particular XSR.

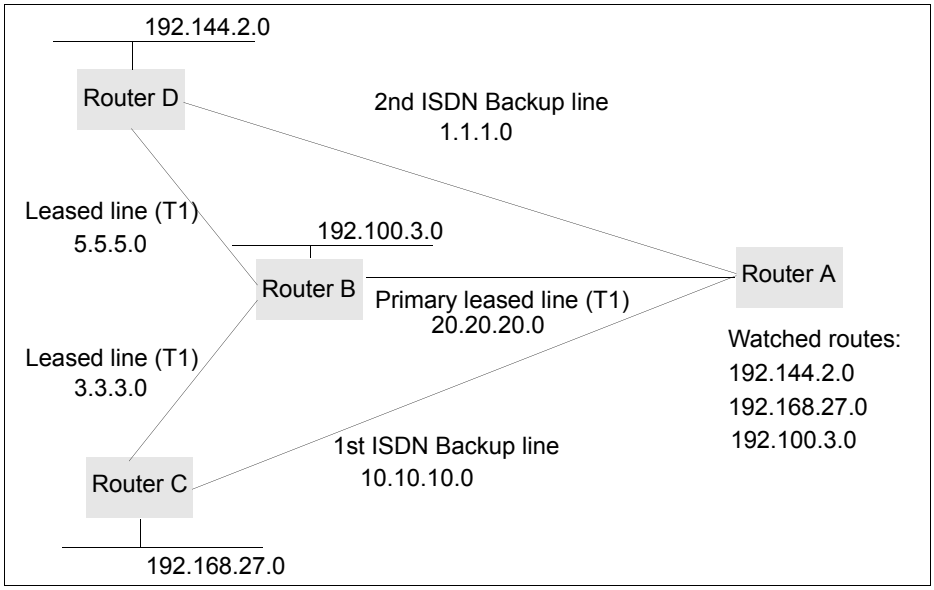
The XSR's backup functionality is implemented by the Dialer subsystem and configured under Interface dialer mode. Each dialer interface used to back up watched routes must be configured with one or more dialer watch-groups, by the **`dialer watch-group`** command, linked to each other by the *same* number.

A watch group can also be specified for use by the Virtual Router Redundancy Protocol (VRRP) with the **`vrrp <number> track watch-group`** command. For more information, refer to "Configuring IP" on page 1.

At the outset, the XSR's Routing Table Manager (RTM) notifies the Dialer subsystem when a route is added or deleted from the routing table. Then, based on the configuration, the Dialer decides to start backup using a preconfigured profile including information such as the *dialer string*, *dialer pool*, *IP address*, and other values as described in this chapter.

In the star topology illustrated in Figure 10-9, Routers A, B, C and D have connectivity to all peers through primary leased lines. Whenever one or two of the primary connections go down, Router A will re-establish total connectivity by bringing up one or two backup switched lines.

Figure 10-9 Dialer Watch Topology



Dialer Watch Behavior

The XSR performs Dialer Watch monitoring in the following sequence:

- Whenever a watched route is deleted, Dialer Watch checks to see if there is at least one valid route for the defined watched IP address
- If no valid route exists, the primary line is considered down and unusable.
- If a valid route exists for the at least one defined IP address on the watch list, and if the route is pointing to an interface other than the backup interface configured for Dialer Watch, the primary link is considered up.
- If the primary link goes down, Dialer Watch is immediately notified by the routing protocol and the secondary link brought up.
- If the primary link remains down, the secondary link stays up indefinitely.
- If the primary link is up, the secondary backup link is disconnected. Additionally, you can set a disable timer to create a delay for the secondary link to disconnect after the primary link is re-established.

Caveat

The following caveat applies to Dialer Watch functionality:

The dialer *will not disconnect* the secondary backup switched link if this connection has a better cost to the watched route than the primary link. But, you can remedy this situation by entering the **`ip rip offset`** command. Adding an offset on an interface makes it a backup port.

Answering Incoming ISDN Calls

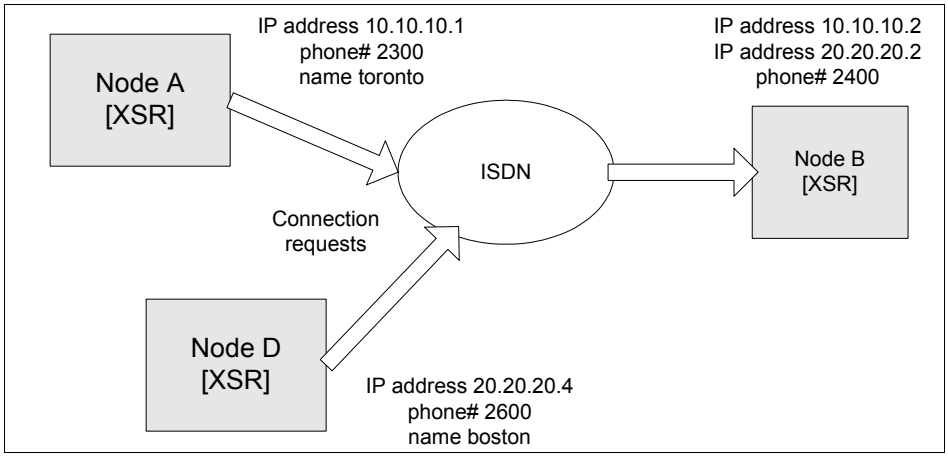
The XSR handles incoming ISDN calls as follows:

- Always accepts incoming calls.
- If there is only one dialer interface configured it will bind the incoming call to that interface.
- If there is more than one dialer interface configured, the XSR will attempt to map the incoming call to only one of these interfaces based on any of the following data passed by the ISDN switch:
  - Called number
  - Calling number
- Mapping based on the *called number* is performed if the following conditions are met:
  - The ISDN switch passes called number data to the XSR. Note that not all types of switches can provide this information.
  - The called number is configured under the target dialer interface using the **`dialer called`** command.
- Mapping based on the *calling number* is performed if the following conditions are met:
  - The ISDN switch passes the calling number to the XSR data. Note that not all types of switches can provide this information.
  - The calling number is configured under the target dialer interface using the **`dialer caller`** command.
- Incoming calls may be mapped to a dialer interface based on the PPP authenticated username if the following conditions are met:
  - The username must be configured under the dialer interface using the **`dialer remote-name`** command.
  - Interface dialer 0 is configured with the desired PPP authentication (e.g., **`ppp authentication pap`**).
- In the case where a dialer interface is configured for *multipoint* operation using the **`dialer map`** command, incoming calls are mapped based on the *calling* number matching the *dialer string* set by the map or on the PPP authenticated *username* matching the name set by the **`dialer map`** command.
- In the case where no dialer interface is found using the methods described above, the XSR will display a high severity alarm stating *cannot bind inbound call* and will disconnect the ISDN call.

Incoming Call Mapping Example

This example, as shown in Figure 10-10, configures a node capable of handling multiple call setup requests coming from different remote peers and maps each incoming call to the correct IP interface (Dialer interface).

Figure 10-10 Incoming Call Mapping Topology



Node A (Calling Node) Configuration

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 25
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands define a dialer group, add a dialer pool, set a 25-second idle timeout, and map BRI interface 1/0 to Dialer interface 1. The **`dialer map`** command directs Node A to call Node B, specifying Node B's IP address and phone number as well as enables spoofing on the network. Optionally, you can specify a clear text password be sent to the peer for PAP authentication.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)dialer pool 25
XSR(config-if<D1>)encapsulation ppp
! XSR(config-if<D1>)#ppp pap sent-username toronto password q
XSR(config-if<D1>)dialer idle-timeout 20
XSR(config-if<D1>)dialer-group 3
XSR(config-if<D1>)dialer map ip 10.10.10.2 2400
XSR(config-if<D1>)ip address 10.10.10.1 255.255.255.0
```

The following command defines *interesting* packets for the dial out trigger by configuring ACL 101 to pass all Type 8 source and destination ICMP packets up to 20 idle seconds:

```
XSR(config)#access-list 101 permit icmp any any 8
```

The following command maps ACL 101 to dialer group 3:

```
XSR(config)#dialer-list 3 protocol ip list 101
```

Node B (Called Node) Configuration

The following commands add two users to validate calls made from Node A. This configuration employs the *username/authentication* method of mapping incoming calls.

```
XSR(config)#username toronto privilege 0 password cleartext z
XSR(config)#username boston privilege 0 password cleartext y
```

These commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 22
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands configure Dialer inter 0 on BRI interface 1/0:

```
XSR(config)#interface dialer 0
XSR(config-if<D0>)encapsulation ppp
XSR(config-if<D0>)ppp authentication pap
```

The following commands add a dialer pool and map BRI interface 1/0 to Dialer interface 1. The **dialer called** command maps incoming Node A calls to Node B's 2400 number. Optionally, you can employ the *dialer caller* method and specify a PPP authenticated username to map incoming calls.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)dialer pool 22
XSR(config-if<D1>)encapsulation ppp
XSR(config-if<D1>)dialer called 2400
! dialer caller 2300
! dialer remote-name toronto
XSR(config-if<D1>)ip address 10.10.10.2 255.255.255.0
```

The following commands add a dialer pool and map BRI interface 1/0 to Dialer interface 2. The **dialer called** command maps incoming Node A calls to Node B's 2400 number. Optionally, you can employ the *dialer caller* method and specify a PPP authenticated username to map incoming calls.

```
XSR(config)#interface dialer 2
XSR(config-if<D2>)#no shutdown
XSR(config-if<D2>)#dialer pool 22
XSR(config-if<D2>)#dialer called 2400
! dialer caller 2600
! dialer remote-name boston
XSR(config-if<D2>)#encapsulation ppp
XSR(config-if<D2>)#ip address 20.20.20.2 255.255.255.0
```

The following command shuts down the SNMP server to avoid saving extraneous messages:

```
XSR(config)#snmp-server disable
```

Node D (Calling Node) Configuration

These commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
```

```
XSR(config-if<BRI-1/0>)#dialer pool-member 2
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands define a dialer group, add a dialer pool, set a 20-second idle timeout, and map BRI interface 1/0 to Dialer port 1. The **dialer map** command directs Node D to call Node B, specifying Node B's IP address and phone number as well as enables spoofing on the network. Optionally, you can set a clear text password be sent to the peer for PAP authentication.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)dialer pool 2
XSR(config-if<D1>)encapsulation ppp
! ppp pap sent-username boston password orbitor
XSR(config-if<D1>)dialer idle-timeout 20
XSR(config-if<D1>)dialer-group 7
XSR(config-if<D1>)dialer map ip 20.20.20.2 2400
XSR(config-if<D1>)ip address 20.20.20.4 255.255.255.0
```

The following command defines *interesting* packets for the dial out trigger by configuring ACL 106 to pass all Type 8 source and destination ICMP packets up to 20 idle seconds:

```
XSR(config)access-list 106 permit icmp any any 8
```

The following command maps ACL 1061 to dialer group 7:

```
XSR(config)#dialer-list 7 protocol ip list 106
```

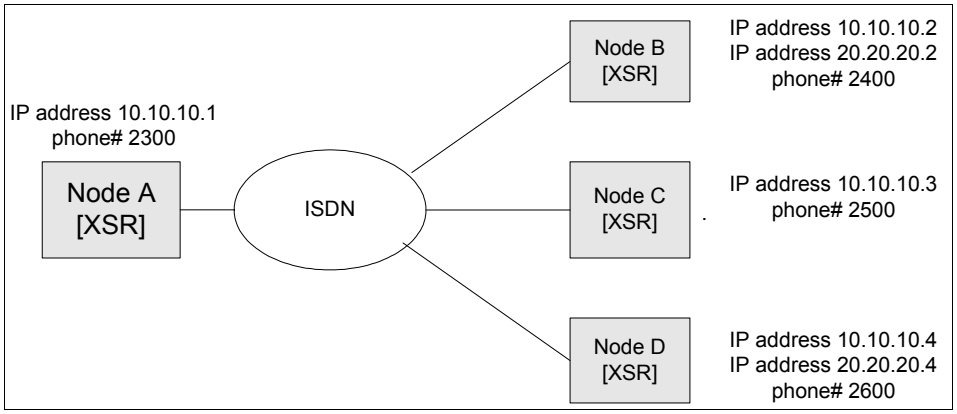
Configuring DoD/BoD

The XSR supports Bandwidth-on-Demand (BoD), the ability to *dynamically* change bandwidth during a multilink connection. DoD/BoD is performed by configuring the following on a multilink bundle:

- The dialer *idle timeout* value to bring down an idle link when triggered by interesting traffic specified by an Access Control List (ACL). The link is brought down by the calling node.
- The multilink *load threshold* to trigger the dialer to add or delete a link. This feature is controlled by the calling node.
- The *minimum links* value to maintain on the bundle. This feature is controlled by the calling node.
- Bandwidth Allocation Protocol (*BAP*) values to negotiate with the peer to add or drop links.

For information on configuring BAP on Dialer interfaces, refer to "Configuring PPP" on page 8-1. An example of the XSR's Dial on Demand functionality is illustrated in the topology shown in Figure 10-11 on page 10-24.

Figure 10-11 Dial on Demand Topology



Note: Configuration commands preceded by exclamation points are optional.

PPP Point-to-Multipoint Configuration

In this configuration, only one of the peer nodes can initiate the setup of a switched link when access-list defined data traffic is sent to the remote peer.

Node A (Calling Node) Configuration

The following commands add a dialer pool and dialer group, and set the Central Office switch type on BRI port 1/0. The commands also configure Dialer interface 1 with spoofing enabled on Node A's network, and set calls out to Node B to terminate if the line is idle for 20 seconds.

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 25
XSR(config-if<BRI-1/0>)#no shutdown
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 25
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer idle-timeout 20
XSR(config-if<D1>)#dialer-group 3
XSR(config-if<D1>)#dialer map ip 10.10.10.2 2400
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
```

The following optional commands can be entered to add a second, similarly configured, Dialer interface to the dialer group:

```
! XSR(config)#interface dialer 2
! XSR(config-if<D2>)#no shutdown
! XSR(config-if<D2>)#dialer pool 25
! XSR(config-if<D2>)#encapsulation ppp
! XSR(config-if<D2>)#dialer idle-timeout 20
! XSR(config-if<D2>)#dialer-group 3
```

```
! XSR(config-if<D2>)#dialer map ip 20.20.20.2 2401
! XSR(config-if<D2>)#ip address 20.20.20.1 255.255.255.0
```

The following command defines *interesting* packets for the dial out trigger by configuring access list 101 to pass all Type 8 source and destination ICMP traffic up to 20 idle seconds:

```
XSR(config)#access-list 101 permit icmp any any 8
```

The following command maps ACL 101 to dialer group 3:

```
XSR(config)#dialer-list 3 protocol ip list 101
```

Node B (Called Node) Configuration

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 22
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands add a dial pool and map BRI interface 1/0 to Dialer interface 1. Optionally, you can employ the *dialer called* method to map incoming Node A calls to Node B's phone number and add a second Dialer interface with similar mappings.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 22
XSR(config-if<D1>)#encapsulation ppp
! dialer called 2400
XSR(config-if<D1>)#ip address 10.10.10.2 255.255.255.0
! XSR(config)#interface dialer 2
! XSR(config-if<D2>)#no shutdown
! XSR(config-if<D2>)#dialer pool 22
! XSR(config-if<D2>)#encapsulation ppp
! XSR(config-if<D2>)#dialer called 2401
! XSR(config-if<D2>)#ip address 20.20.20.2 255.255.255.0
```

PPP Multipoint-to-Multipoint Configuration

The following configuration sets both peer nodes to initiate the setup of a switched link when access list-defined data traffic is sent to the remote peer. The configuration of the two nodes is symmetrical, that is, both nodes can make and receive calls.

Node A Configuration

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 25
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands define a dial group, add a dial pool, configure Dialer interface 1 with spoofing enabled on *XSR-Andover* network, and set calls out to *XSR-Toronto* to terminate if the line is idle for 35 seconds:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 25
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer idle-timeout 35
XSR(config-if<D1>)#dialer-group 3
XSR(config-if<D1>)#dialer map ip 10.10.10.2 2400
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
```

The following command defines *interesting* packets for the dial out trigger by configuring access list 101 to pass all Type 8 source and destination ICMP traffic up to 35 idle seconds:

```
XSR(config)#access-list 101 permit icmp any any 8
```

The following command maps ACL 101 to dialer group 3:

```
XSR(config)#dialer-list 3 protocol ip list 101
```

Node B Configuration

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 22
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands add a dialer pool and dialer group, and specify MLPPP call destination *Node A* on *Node B's* Dialer interface 1. If the line is idle for 30 seconds, it is brought down.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 22
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer-group 7
XSR(config-if<D1>)#dialer idle-timeout 30
XSR(config-if<D1>)#dialer map ip 10.10.10.1 2300
XSR(config-if<D1>)#ip address 10.10.10.2 255.255.255.0
```

The following command defines *interesting* packets for the dial out trigger by configuring access list 105 to pass all Type 8 source and destination ICMP traffic up to 30 idle seconds:

```
XSR(config)#access-list 105 permit icmp any any 8
```

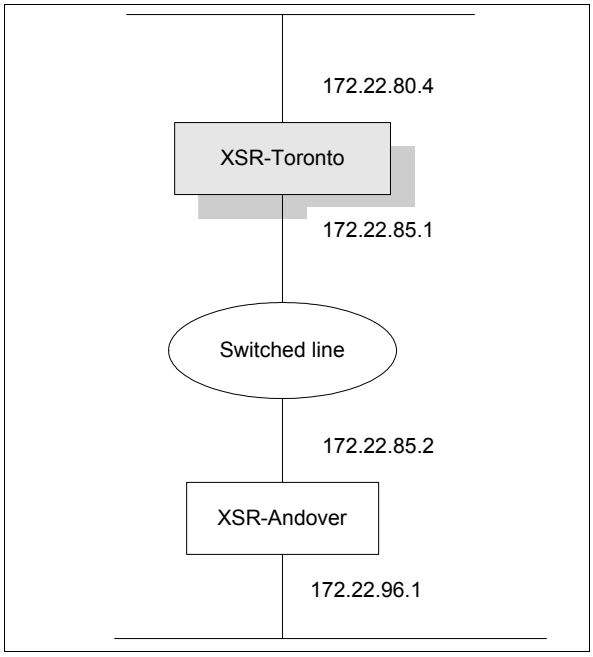
The following command maps ACL 105 to dialer group 7:

```
XSR(config)#dialer-list 7 protocol ip list 105
```

PPP Point-to-Point Configurations

The following sample configuration is a PPP *point-to-point* topology, as illustrated in Figure 10-12

Figure 10-12 Point-to-Point Topology



Dial-in Routing for Dial on Demand Example

The following commands configure dialer interface 1*:*

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 172.22.85.1
XSR(config-if<D1>)#ppp authentication pap
+ Enforces authentication username XSR-Andover to map incoming calls on XSR Toronto
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer remote-name XSR-andover
+ Specifies the authenticated username
XSR(config-if<D1>)#no shutdown
```

The following command configures authentication of the remote user:

```
XSR(config)#username XSR-andover password secret 0 code
```

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 1
XSR(config-if<BRI-1/0>)#no shutdown
```

Dial-out Routing for Dial on Demand Example

The following commands define a dial group, add a dial pool, specify a secret password to be sent to the peer for PAP authentication, and configure Dialer interface 1 with spoofing enabled on *XSR-Andover* network:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 172.22.85.2
XSR(config-if<D1>)#ppp pap sent-username XSR-andover password secret 0 dolly
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer string 47410
XSR(config-if<D1>)#dialer-group 1
+ Defines interesting packets to trigger dial out
XSR(config-if<D1>)#dialer idle-timeout 20
+ Terminates call to Toronto if the line is idle for 20 seconds
XSR(config-if<D1>)#no shutdown
```

The following commands add a dial pool member and set the Central Office switch type on BRI interface 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 1
XSR(config-if<BRI-1/0>)#no shutdown
```

The following command maps ACL 101 to dialer group 1:

```
XSR(config)#dialer-list 1 protocol ip list 101
```

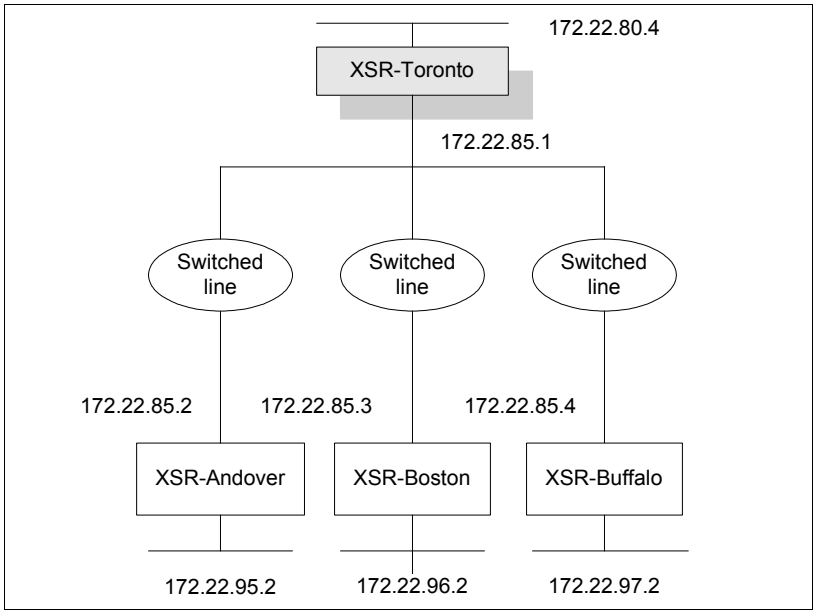
The following command defines *interesting* packets for the dial out trigger by configuring access list 101 to pass all Type 8 source and destination ICMP traffic up to 20 idle seconds:

```
XSR(config)#access-list 101 permit icmp any any 8
```

PPP Point-to-Multipoint Configurations

The following topology can be used for Dial on Demand applications only; it cannot be used for Dialed Backup applications. Refer to Figure 10-13.

Figure 10-13 PPP Point-to-Multipoint Topology



Dial-out Router Example

The following commands add a dialer pool and dialer group, specify a secret password to be sent to the peer for PAP authentication, and specify three MLPPP call destinations - *XSR-Andover, XSR-Boston* and *XSR-Buffalo* - on *XSR-Toronto's* Dialer interface 1. Spoofing is enabled by the **`dialer map`** command.

```
XSR(config)#interface dialer 1 multi-point
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 172.22.85.1
XSR(config-if<D1>)#ppp pap sent-username XSR-toronto password secret 0 xxgene
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer map ip 172.22.85.2 4710
XSR(config-if<D1>)#dialer map ip 172.22.85.3 89302
XSR(config-if<D1>)#dialer map ip 172.22.85.4 672783
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer-group 1
```

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 1
XSR(config-if<BRI-1/0>)#no shutdown
```

The following command maps ACL 101 to dialer group 1:

```
XSR(config)#dialer-list 1 protocol ip list 101
```

The following command defines *interesting* packets for the dial out trigger by configuring ACL 101 to pass Type 8 source and destination ICMP packets:

```
XSR(config)#access-list 101 permit icmp any any 8
```

Dial-in Router Example

The following commands configure Dialer interface 0:

```
XSR(config)#interface dialer 0
+ Enforces authentication for incoming calls
XSR(config-if<D0>)#encapsulation ppp
XSR(config-if<D0>)#ppp authentication pap
```

The following commands add a dialer pool and specify the PPP authenticated username of *XSR-Toronto* calling in to Dialer interface 1:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 172.22.85.2
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer remote-name XSR-toronto
```

The following commands add a dial pool and specifies the PPP authenticated username *XSR-Boston* to map incoming calls to Dialer interface 2:

```
XSR(config)#interface dialer 2
XSR(config-if<D2>)#encapsulation ppp
XSR(config-if<D2>)#ip address 172.22.85.3
XSR(config-if<D2>)#dialer pool 1
```

```
XSR(config-if<D2>)#no shutdown
XSR(config-if<D2>)#dialer remote-name XSR-Boston
```

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 1
XSR(config-if<BRI-1/0>)#no shutdown
```

The following command sets remote user authentication:

```
XSR(config)#username XSR-toronto password secret 0 code
```

MLPPP Point-to-Multipoint Configuration

The following configuration, as illustrated in Figure 10-12 on page 10-27, sets up a switched MLPPP group (bundle) when Access List-defined data traffic is generated to a remote site.

Note: Only peer Node A can *initiate* the MLPPP group setup.

Node A (Calling Node) Configuration

The following commands add a dialer pool member with the Central Office switch type to BRI interface 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 25
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands define a dialer group, add a dialer pool, enable MLPPP, set a 20-second idle timeout, and map BRI interface 1/0 to Dialer interface 1. The **`min-links`** command directs the XSR to maintain a minimum of two links over the switched line. The **`dialer map`** command directs Node A to call Node B, specifying Node B's IP address and phone number, as well as enables spoofing.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 25
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer idle-timeout 20
XSR(config-if<D1>)#dialer-group 3
XSR(config-if<D1>)#dialer map ip 10.10.10.2 2400
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<D1>)#ppp multilink
XSR(config-if<D1>)#multilink min-links 2
```

The following command defines *interesting* packets for the dial out trigger by configuring ACL 101 to permit all Type 8 source and destination ICMP traffic:

```
XSR(config)#access-list 101 permit icmp any any 8
```

The following command maps ACL 101 to dialer group 3:

```
XSR(config)#dialer-list 3 protocol ip list 101
```

Node B (Called Node) Configuration

The following commands add a dialer pool member with the Central Office switch type to BRI interface 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 22
XSR(config-if<BRI-1/0>)#no shutdown
```

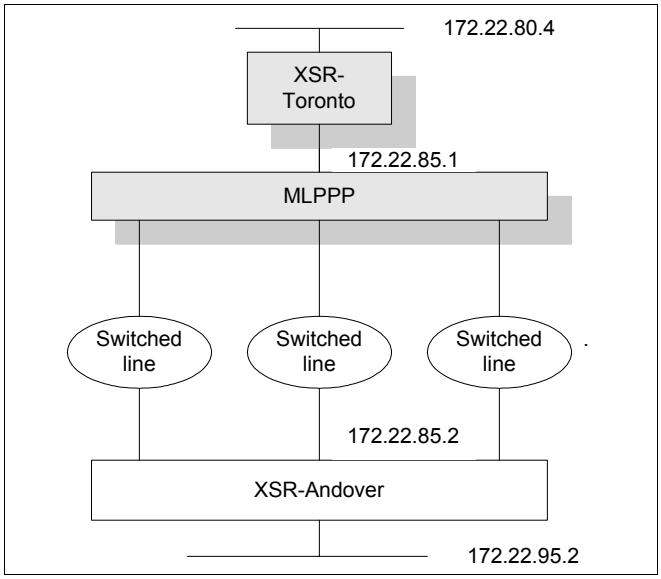
The commands below add a dialer pool and enable MLPPP on Dialer port 1:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 22
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.2 255.255.255.0
XSR(config-if<D1>)#ppp multilink
```

MLPPP Point-to-Point Configurations

The following MLPPP point-to-point topology can be used for Bandwidth on Demand applications, as illustrated by Figure 10-14. This example creates three switched lines linking users on *XSR-Toronto's* network with those on *XSR-Andover's* network.

Figure 10-14 MLPPP Point-to-Point Topology



Dial-in Router Example

The following commands add a dialer pool and configure Multilink PPP on *XSR-Toronto's* Dialer interface 1:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 172.22.85.1
XSR(config-if<D1>)#ppp multilink
```

```
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#no shutdown
```

The following commands add a dialer pool member and specify the primary-ni switch on *XSR-Toronto's* T1 interface 2/3:

```
XSR(config)#controller t1 2/3
XSR(config-controller<T1-1/1>)#switch-type primary-ni
XSR(config-controller<T1-1/1>)#dialer pool-member 1
XSR(config-controller<T1-1/1>)#no shutdown
```

Dial-out Router Example

The following commands add a dialer pool and dialer group and specify the call destination - *XSR-Toronto* on *XSR-Andover's* Dialer interface 1.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 172.22.85.2
XSR(config-if<D1>)#ppp multilink
XSR(config-if<D1>)#multilink min-links 2
+ Brings up a minimum of 2 links on XSR-Andover's Dialer interface 1
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer string 47410
XSR(config-if<D1>)#dialer-group 1
```

These commands add a pool member and configure the primary-ni switch on T1 interface 2/3:

```
XSR(config)#controller t1 2/3
XSR(config-controller<T1-2/3>)#switch-type primary-ni
XSR(config-controller<T1-2/3>)#dialer pool-member 1
XSR(config-controller<T1-2/3>)#no shutdown
```

The following command maps ACL 101 to dialer group 1:

```
XSR(config)#dialer-list 1 protocol ip list 101
```

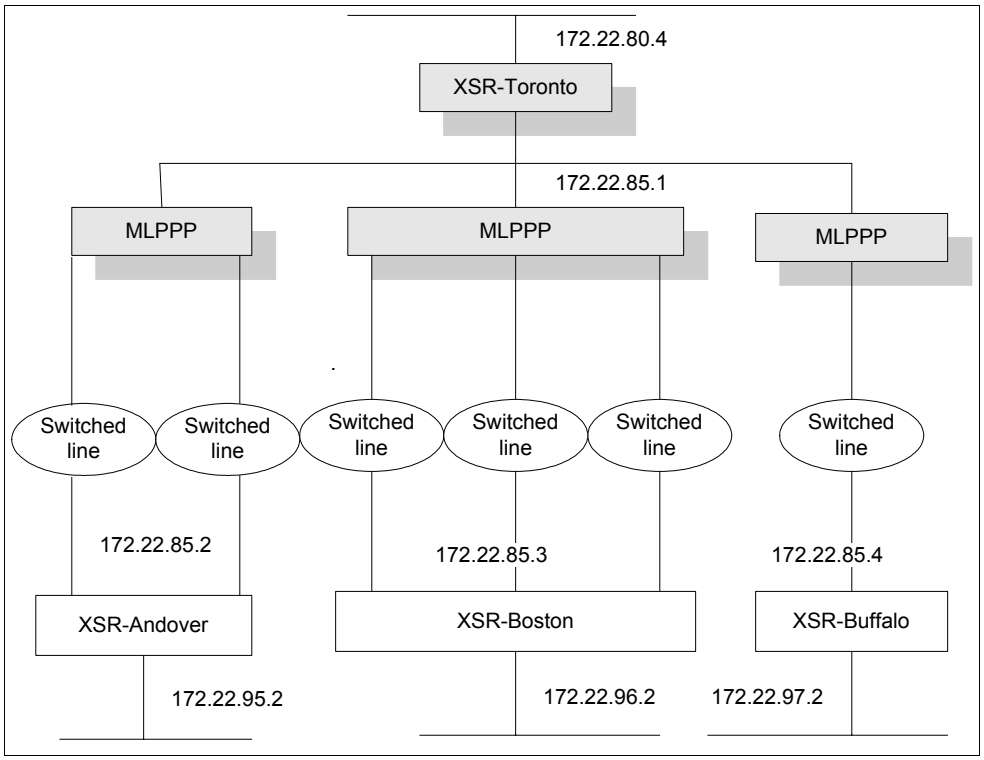
The following command defines *interesting* packets for the dial out trigger by configuring ACL 101 to pass all Type 8 source and destination ICMP traffic up to 20 idle seconds:

```
XSR(config)#access-list 101 permit icmp any any 8
```

MLPPP Point-to-Multipoint Configurations

The following MLPPP point-to-multipoint topology can be used for BoD applications, as illustrated by Figure 10-15. This example creates multiple switched lines linking users on *XSR-Toronto's* network with those on three remote networks.

Figure 10-15 MLPPP Point-to-Multipoint Topology



Dial-out Router Example

The following commands add a dialer pool and dialer group, and specify three MLPPP call destinations - *XSR-Andover, XSR-Boston* and *XSR-Buffalo* - on *XSR-Toronto's* Dialer interface 1. Spoofing also is enabled by the **`dialer map`** command.

```
XSR(config)#interface dialer 1 multi-point
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 172.22.85.1
XSR(config-if<D1>)#ppp multilink
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#dialer map ip 172.22.85.2 47410
XSR(config-if<D1>)#dialer map ip 172.22.85.3 425688
XSR(config-if<D1>)#dialer map ip 172.22.85.4 987762
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer-group 1
```

The following commands add a pool member and configure the primary-ni switch on T1 interface 2/3:

```
XSR(config)#controller t1 2/3
XSR(config-controller<T1-2/3>)#switch-type primary-ni
XSR(config-controller<T1-2/3>)#dialer pool-member 1
XSR(config-controller<T1-2/3>)#no shutdown
```

The following command maps ACL 101 to dialer group 1:

```
XSR(config)#dialer-list 1 protocol ip list 101
```

The following command defines *interesting* packets for the dial out trigger by configuring ACL 101 to pass all Type 8 source and destination ICMP packets:

```
XSR(config)#access-list 101 permit icmp any any 8
```

Dial-in Router Example

The following commands add a dialer pool and configure PPP Multilink on *XSR-Andover's* Dialer interface 1:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 172.22.85.2
XSR(config-if<D1>)#ppp multilink
XSR(config-if<D1>)#dialer pool 1
XSR(config-if<D1>)#no shutdown
```

The following commands add a pool member and configure the primary-ni switch on T1 interface 2/3:

```
XSR(config)#controller t1 2/3
XSR(config-controller<T1-2/3>)#switch-type primary-ni
XSR(config-controller<T1-2/3>)#dialer pool-member 1
XSR(config-controller<T1-2/3>)#no shutdown
```

MLPPP Multipoint-to-Multipoint Configuration

The following configuration, as shown in Figure 10-11, enables the setup of a switched MLPPP group when access list-defined data traffic is sent to a remote site. Both peer nodes can initiate and accept switched MLPPP calls.

Node A Configuration

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 25
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands add a dialer pool and dialer group, and specify MLPPP call destination *Node B* on *Node A's* Dialer interface 1. If the line is idle for 20 seconds, it is brought down.

```
XSR(config)#interface dialer 1 multi-point
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 25
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer idle-timeout 20
XSR(config-if<D1>)#dialer-group 3
XSR(config-if<D1>)#dialer map ip 10.10.10.2 2400
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<D1>)#ppp multilink
```

The following command defines *interesting* packets for the dial out trigger by configuring ACL 101 to pass all Type 8 source and destination ICMP packets up to 20 idle seconds:

```
XSR(config)#access-list 101 permit icmp any any 8
```

The following command maps ACL 101 to dialer group 3:

```
XSR(config)#dialer-list 3 protocol ip list 101
```

Node B Configuration

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 22
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands add a dialer pool and dialer group, and specify MLPPP call destination *Node A* on *Node B's* Dialer interface 1. Spoofing also is enabled by the **`dialer map`** command.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 22
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.2 255.255.255.0
XSR(config-if<D1>)#dialer-group 3
XSR(config-if<D1>)#dialer idle-timeout 20
XSR(config-if<D1>)#dialer map ip 10.10.10.1 2300
XSR(config-if<D1>)#ppp multilink
```

The following command defines *interesting* packets for the dial out trigger by configuring ACL 101 to pass all Type 8 source and destination ICMP packets up to 20 idle seconds:

```
XSR(config)#access-list 101 permit icmp any any 8
```

The following command maps ACL 101 to dialer group 3:

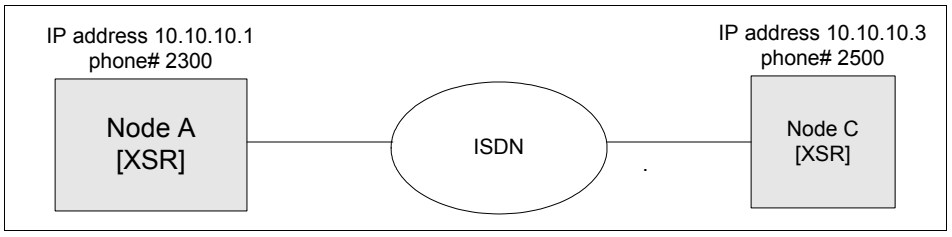
```
XSR(config)#dialer-list 3 protocol ip list 101
```

Switched PPP Multilink Configuration

Bandwidth-on-Demand

This example configures multilink PPP over ISDN together with BoD as shown in Figure 10-16.

Figure 10-16 MLPPP Bandwidth on Demand Topology



Node A (Calling Node) Configuration

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 23
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands define a dialer group, add a dialer pool, enable MLPPP, set a load threshold of 3 links, and map BRI interface 1/0 to Dialer interface 1. The **load-threshold** command enables BoD by making the
XSR maintain three links over the switched line. The **dialer map** command directs Node A to call Node C, specifying Node C's IP address and phone number as well as enables spoofing on the network.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 23
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<D1>)#dialer map ip 10.10.10.3 2500
XSR(config-if<D1>)#ppp multilink
XSR(config-if<D1>)#dialer-group 7
XSR(config-if<D1>)#multilink load-threshold 3
XSR(config-if<D1>)#dialer idle-timeout 20
```

The following command defines *interesting* packets for the dial out trigger by configuring ACL 106 to pass all Type 8 source and destination ICMP packets up to 20 idle seconds:

```
XSR(config)#access-list 106 permit icmp any any 8
```

The following command maps ACL 106 to dialer group 7:

```
XSR(config)#dialer-list 7 protocol ip list 106
```

Node C (Called Node) Configuration

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 2
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands add a dialer pool, enable MLPPP, and map BRI interface 1/0 to Dialer interface 1. The **dialer called** command maps incoming Node A calls to its 2500 number:

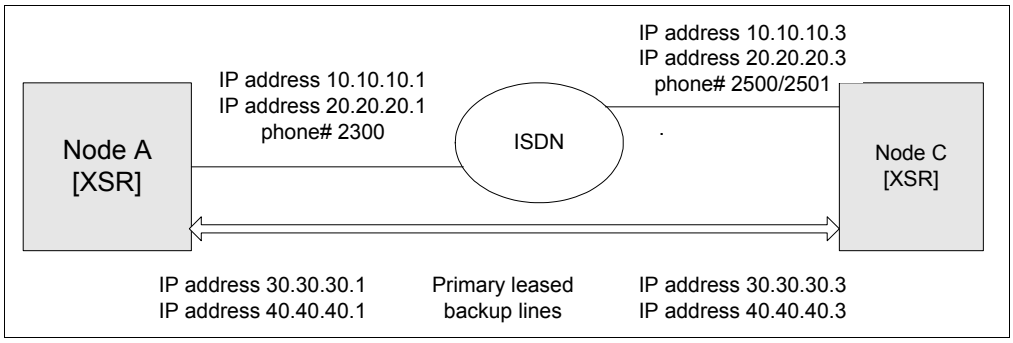
```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 2
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer called 2500
XSR(config-if<D1>)#ip address 10.10.10.3 255.255.255.0
XSR(config-if<D1>)#ppp multilink
```

Backup Configuration

Backup Using ISDN

This example configures ISDN NIM cards (either BRI or T1/E1 configured for PRI) to be used for backing-up other interfaces, as shown in Figure 10-17.

Figure 10-17 Backup Topology Using ISDN



Node A (Backed-up Node) Configuration

The following commands set internal clocking and configure two channel groups with three total timeslots on T1 sub-interface 1/2:0:

```
XSR(config)#controller t1 1/2/0
XSR(config-controller<T1-1/2:0>)#clock source internal
XSR(config-controller<T1-1/2:0>)#channel-group 1 timeslots 2
XSR(config-controller<T1-1/2:0>)#channel-group 0 timeslots 1
XSR(config-controller<T1-1/2:0>)#no shutdown
```

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 22
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands add a dialer pool, set Node C's dialer number to call, specify a clear text password sent to the peer for PAP authentication, and map BRI interface 1/0 to Dialer interface 1.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 22
XSR(config-if<D1>)#dialer string 2500
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<D1>)#ppp pap sent-username toronto password ab
```

The following commands add a dialer pool, set Node C's dialer number to call, and map BRI interface 1/0 to Dialer interface 2:

```
XSR(config)#interface dialer 2
XSR(config-if<D2>)#no shutdown
```

```
XSR(config-if<D2>)#dialer pool 22
XSR(config-if<D2>)#dialer string 2501
XSR(config-if<D2>)#ip address 20.20.20.1 255.255.255.0
```

The following command configures backup Dialer interface 1 on Serial sub-interface 2/0:0:

```
XSR(config)#interface serial 2/0:0
XSR(config-if<S2/0:0>)#no shutdown
XSR(config-if<S2/0:0>)#backup interface dialer1
XSR(config-if<S2/0:0>)#encapsulation ppp
XSR(config-if<S2/0:0>)#ip address 30.30.30.1 255.255.255.0
```

The following command configures backup Dialer interface 2 on Serial sub-interface 2/0:1:

```
XSR(config)#interface serial 2/0:1
XSR(config-if<S2/0:1>)#no shutdown
XSR(config-if<S2/0:1>)#backup interface dialer 2
XSR(config-if<S2/0:1>)#encapsulation ppp
XSR(config-if<S2/0:1>)#ip address 40.40.40.1 255.255.255.0
```

Node C (Called Node) Configuration

The following command configures a Node A user for authentication:

```
XSR(config)#username toronto privilege 0 password cleartext z
```

The following commands configure two channel groups with a total of three timeslots on T1 sub-interface 1/2:0:

```
XSR(config)#controller t1 1/2/0
XSR(config-controller<T1-1/2:0>)#channel-group 1 timeslots 2
XSR(config-controller<T1-1/2:0>)#channel-group 0 timeslots 1
XSR(config-controller<T1-1/2:0>))#no shutdown
```

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 28
XSR(config-if<BRI-1/0>)#no shutdown
```

One of the following commands sets PAP authentication on Dialer interface 0:

```
XSR(config)#interface dialer 0
XSR(config-if<D0>)#encapsulation ppp
XSR(config-if<D0>)#ppp authentication pap
```

The following commands add a dialer pool and specify the PPP authenticated username *Toronto* to map incoming calls on Dialer interface 1:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 28
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#dialer remote-name Toronto
XSR(config-if<D1>)#ip address 10.10.10.3 255.255.255.0
```

The following commands add a dialer pool and map incoming Node A calls to Node C's 2500 number:

```
XSR(config)#interface dialer 2
```

```
XSR(config-if<D2>)#no shutdown
XSR(config-if<D2>)#dialer pool 28
XSR(config-if<D2>)#encapsulation ppp
XSR(config-if<D2>)#dialer called 2501
XSR(config-if<D2>)#ip address 20.20.20.3 255.255.255.0
```

The following command configures Serial sub-interface 2/0:0:

```
XSR(config)#interface serial 2/0:0
XSR(config-if<S2/0:0>)#no shutdown
XSR(config-if<S2/0:0>)#encapsulation ppp
XSR(config-if<S2/0:0>)#ip address 30.30.30.3 255.255.255.0
```

The following command configures Serial sub-interface 2/0:1:

```
XSR(config)#interface serial 2/0:1
XSR(config-if<S2/0:1>)#no shutdown
XSR(config-if<S2/0:1>)#encapsulation ppp
XSR(config-if<S2/0:1>)#ip address 40.40.40.3 255.255.255.0
```

Configuration for Backup with MLPPP Bundle

Node A (Backed-up Node) Configuration

The following commands set internal clocking and configure two channel groups with three total timeslots on T1 sub-interface 1/2:0:

```
XSR(config)#controller t1 1/2/0
XSR(config-controller<T1-1/2:0>)#clock source internal
XSR(config-controller<T1-1/2:0>)#channel-group 1 timeslots 2
XSR(config-controller<T1-1/2:0>)#channel-group 0 timeslots 1
XSR(config-controller<T1-1/2:0>)#no shutdown
```

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 22
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands add a dialer pool, enable MLPPP, specify Node A to call Node C by entering Node C's phone number, and map BRI interface 1/0 to Dialer interface 1. The **`min-links`** command directs the XSR to maintain a minimum of two links over the switched line.

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 22
XSR(config-if<D1>)#dialer string 2500
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<D1>)#ppp multilink
XSR(config-if<D1>)#multilink min-links 2
```

The following command configures Serial sub-interface 2/0:0:

```
XSR(config)#interface serial 2/0:0
XSR(config-if<S2/0:0>)#no shutdown
```

```
XSR(config-if<S2/0:0>)#backup interface dialer1
XSR(config-if<S2/0:0>)#encapsulation ppp
XSR(config-if<S2/0:0>)#ip address 30.30.30.1 255.255.255.0
```

Node C (Called Node) Configuration

The following commands configure two channel groups with three total timeslots on T1 sub-interface 0/2:0:

```
XSR(config)#controller t1 0/2/0
XSR(config-controller<T1-0/2:0>)#channel-group 1 timeslots 2
XSR(config-controller<T1-0/2:0>)#channel-group 0 timeslots 1
XSR(config-controller<T1-0/2:0>)#no shutdown
```

The following commands add a dialer pool member and set the Central Office switch type on BRI port 1/0:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-net3
XSR(config-if<BRI-1/0>)#dialer pool-member 28
XSR(config-if<BRI-1/0>)#no shutdown
```

The following commands add a dialer pool, enable MLPPP, and map BRI interface 1/0 to Dialer interface 1:

```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#no shutdown
XSR(config-if<D1>)#dialer pool 28
XSR(config-if<D1>)#encapsulation ppp
XSR(config-if<D1>)#ip address 10.10.10.3 255.255.255.0
XSR(config-if<D1>)#ppp multilink
```

The following commands configure Serial sub-interface 2/0:0:

```
XSR(config)#interface serial 2/0:0
XSR(config-if<S2/0:0>)#no shutdown
XSR(config-if<S2/0:0>)#encapsulation ppp
XSR(config-if<S2/0:0>)#ip address 30.30.30.3 255.255.255.0
```

Configuration for Ethernet Failover

This example provides DSL backup (PPPoE) on a FastEthernet interface. Dialer interface 57 is configured as the backup for FastEthernet sub-interface 2.1 - invoking the sub-interface enables PPPoE. Note that the IP address of the PPPoE caller is negotiated over PPP and the MTU size is reset to 1492 bytes to avoid Web access problems by PCs attached to the XSR.

```
XSR(config)#interface fastethernet 2.1
XSR(config-if<F2.1>#backup interface dialer 57
XSR(config-if<F2.1>)#encapsulation ppp
XSR(config-if<F2.1>)#ip address negotiated
XSR(config-if<F2.1>)#ip mtu 1492
XSR(config-if<F2.1>)#no shutdown
```

Configuration for Frame Relay Encapsulation

This backup dial-out example configures FR encapsulation and typical call parameters (dial pool, dial string, dial class) on parent Dialer interface 20 while setting the DLCI and IP address on Dialer sub-interface 20.1:

```
XSR(config)#interface dialer 20
XSR(config-if<D20>)#dial pool 3
XSR(config-if<D20>)#dial string 9053617921 class ISDN
XSR(config-if<D20>)#encapsulation frame-relay
XSR(config-if<D20>)#frame-relay lmi-type none
XSR(config-if<D20>)#no shutdown

XSR(config-if<D20>)#interface dialer 20.1 point-to-point
XSR(config-if<D20.1>)#ip address 192.168.20.1 255.255.255.0
XSR(config-if<D20.1>)#frame-relay interface-dlci 16
XSR(config-if<D20.1>)#no shutdown
```

11

Configuring Integrated Services Digital Network

This chapter outlines how to configure the Integrated Services Digital Network (ISDN) Protocol on the XSR in the following sections:

- XSR ISDN features
- Understanding ISDN
- ISDN configuration topology
  - BRI
  - PRI
  - Leased line
- ISDN configuration examples
  - T1 PRI
  - E1 PRI
  - ISDN BRI
  - BRI Leased
  - BRI Leased PPP
  - BRI Leased Frame Relay
- Call Status Call Codes

Caution: Configuration of XSR 1200 Series routers is significantly different than for XSR 1800 and 3000 routers. For example, only interfaces **`FastEthernet 0`**, **`ATM 0`**, and **`BRI 0`** (as well as their sub-interfaces) are configurable on the XSR 1200 Series. For more information, refer to the *XSR 1220/1235 Getting Started Guide*.

ISDN Features

The XSR's BRI interface and T1/E1 controller in PRI mode acts as a utility that can set up and tear down calls under the control of higher level functionality, usually the Dialer. The ISDN module expects to receive from the Dialer a full description of the call to be placed will accept incoming calls only if screened by the Dialer. The XSR's ISDN services BRI and PRI lines via the following NIMs on XSR 1800 and 3000 Series routers:

- 1, 2 or 4 port Channelized NIM card for PRI lines.
- 1 or 2 port BRI-S/T NIM card.
- 1 or 2 port BRI U NIM card.

BRI Features

- Circuit Mode Data (CMD): Channels (DS0s or B's) are switched by the CO to the destination user for the duration of the call.
  - 0utgoing calls supported for Backup, DoD/BoD.
  - Incoming calls routed to the correct protocol stack based on called number/sub-address and calling number/sub-address.
- Permanent B channel support, i.e., 56, 64, 112, 128, or 144 Kbps lease line. Each BRI port can be configured for CMD or Leased-Line mode of operation.
- Supported switch types: *ETSI* for international applications, *NI1*, *5ESS* and *DMS100* in North America and *NTT* in Japan. Layer 1 activation is initiated by incoming or outgoing calls for ETSI and NTT switch types.
- TEI auto-negotiated.
- Q.921/Q.931 (Layer 2/Layer 3) configuration is set automatically by selection of switch type.

PRI Features

- Circuit Mode Data (CMD): Channels (DS0s or B's) are switched by the CO to the destination user for the duration of the call.
  - Outgoing calls supported for Backup, DoD/BoD.
  - Incoming calls routed to the correct protocol stack based on called number/sub-address and calling number/sub-address.
- Supported switch types: *ETSI*, *NI2*, *5ESS*, *DMS100* and *NTT*.
- Handling restart and maintenance modes automatically set.
- Fixed TEI to 0.
- Q921/Q931 (Layer 2/Layer 3) configuration is set automatically by the choosing switch type.
- Not supported on the XSR 1200 Series

Understanding ISDN

Physically, an ISDN line is provisioned via unshielded twisted pair cable which would, in the absence of ISDN service, be used for regular analog telephone service or a T1/E1 connection.

Typically, numerous ISDN devices connect onto this single line through a device known as an NT1 provided by the user in North America and by the carrier most everywhere else. PRI service is terminated in the XSR's T1/E1 NIM the same way as E1 or T1 service. BRI service is connected to the XSR's BRI-S/T NIM via a interface adapter known as NT1. The NT1 is provided by the service provider. Only in North America do users have to provide their own NT1. The BRI U NIM can be connected directly to incoming BRI lines in North America as they include a built-in NT1.

Logically, ISDN consists of two types of communications channels: *bearer* service B-channels, which carry data and services at 64 Kbps; and a single D-channel (*delta*), which usually carries signaling and administrative information which is used to set up and tear down calls. The transmission speed of the D-channel depends on the type of ISDN service you've subscribed to.

Available ISDN services include two categories: Basic Rate Interface (BRI) service, which provides access to two B-channels and a 16 Kbps D-channel; and Primary Rate Interface (PRI) service,

which provides access to 23 B-channels in North America and Japan and 30 B-channels in Europe and most of Asia, and a 64 Kbps D-channel in both.

Basic Rate Interface

The XSR's BRI NIM provides two BRI ports. Each port has two 64 Kbps B-channels and one 16 Kbps D-channel. BRI is configured on the XSR by **`interface bri`** sub-commands.

Primary Rate Interface

ISDN PRI is provisioned over T1 service in North America and Japan and includes one 64 Kbps D-channel and 23 B-channels, and over E1 service includes 30 B-channels in most other parts of the world.

The number of B-channels is limited by the size of the standard trunk line used in the region; T1 in North America and Japan and E1 most everywhere else. Unlike BRI, PRI does not support a bus configuration, and only one device can be connected to a PRI line - point-to-point service.

A single PRI connection is usually much less expensive than obtaining the equivalent number of B-channels through multiple BRI connections. BRI and PRI are used for the same applications, only the number of channels differ. PRI is configured on the XSR by **`controller t1/e1`** sub-commands.

B-Channels

The XSR's B-channels are 56 or 64 Kbps "pipes" also known as DSOs. B-channels typically form circuit-switched connections. Just like a telephone connection, a B-channel connection is an end-to-end physical circuit that is temporarily dedicated to transferring data between two devices. The circuit-switched nature of B-channel connections, combined with their reliability and relatively high bandwidth, makes ISDN suitable for a range of applications including video, fax, and data. They can be used to transfer any Layer 2 or higher protocols across a link. The XSR employs PPP or Multilink PPP over the switched BRI or PRI connections. For more information, refer to the PPP and MLPPP chapters in this manual.

The router's B-channels can also be configured as permanent or *nailed-up* connections which are always *up*, as a leased-line application similar to the channelized T1/E1 application.

D-Channel

The XSR's D-channel is used for signaling, such as instructing the ISDN carrier to set up or tear down a call along a B-channel, to ensure that a B-channel is available to receive an incoming call, or to provide the signaling information that is required for such features as caller identification. The D-channel uses packet-switched connections, which are best adapted to the intermittent but latency-sensitive nature of signaling traffic, thus accounting for the vastly reduced call setup time of 1 to 2 seconds on ISDN calls (vs. 10 to 40 seconds using an analog modem).

Unlike the B-channel, which functions as a simple pipe for user data, the D-channel is associated with higher level protocols, Layer 2: Q.921 and 3: Q.931 of the OSI model.

Q.931 is the call-control protocol component of this definition, although various carriers tend to use variants. This Layer 3 signaling protocol is transferred on the D-channel using Link Access Procedure-D-channel (LAPD): Q.921, a Layer 2 HDLC-like protocol.

D-Channel Standards

The XSR supports several D-channel standards, which are enabled with the **`isdn switch-type`** command. The accepted standards and some associated switches are:

- Europe/ International: *basic-net3* for BRI and *primary-net5* for PRI
- Japan: *basic-ntt* for BRI and *primary-ntt* for PRI
- North America: *basic-ni1* and *basic-dms100* switches for BRI and *primary-ni2*, *primary-5ess*, and *primary-dms100* for PRI

D-Channel Signaling and Carrier Networks

When the ISDN carrier receives a Q.931 instruction from a remote location, for example, to set up a call, it triggers network switches to set up an end-to-end 64 Kbps B-channel between the source and the destination directory number signaled by Q.931. The carrier's network uses a different signaling system though. Signaling between remote ISDN devices and the public voice and data network switches occurs using D-channel protocols such as Q.931, which in turn is converted into Signaling System No. 7 (SS7) signals within the carrier's digital voice and data networks. With SS7, carriers are able to maintain clear channel 64 Kbps connections by communicating signaling data in a distinct channel. The switch at the destination side of the network then communicates with the remote ISDN device using its D-channel protocol.

Unfortunately, SS7 is not always fully implemented, leading to occasional limitations when ISDN links traverse multiple switches. For instance, if one switch does not fully support SS7 ISDN features, call setup and signaling messages must be sent *in-band* or through the same communications channel as the bearer service. In other words, 8 Kbps of a 64 Kbps B-channel must be reserved for signaling, thus reducing available bandwidth.

This explains the 56 in *switched-56* services, which also use 8 Kbps of a 64 Kbps channel for signaling. Any ISDN call that passes through at least one network which lacks full SS7 signaling, must then limit its B-channel traffic to 56 Kbps. In such cases the ISDN equipment on both ends must be configured to put only 56 Kbps of data onto their 64 Kbps link. As networks have continued to modernize, the use of 56 Kbps connection has diminished.

The XSR automatically adapts to the speed of incoming calls, whether 56 or 64 Kbps. When dialing over ISDN in North America, users can set the call speed by specifying 64 (default) or 56 Kbps. If the network can not connect at 64 Kbps, it will be rejected and the router will try to redial (if redial attempts are set). If users wish to be sure that their calls will succeed, the XSR will request all outgoing calls be set at 56 Kbps. Consult "Configuring Dialer Services" on page 10-1 for more detailed information.

To support 56 Kbps, communications equipment at both ends must support a rate *adaptation* scheme which pads bandwidth above 56 Kbps with blank data, using such schemes as V.110 or V.120 rate adaptation. This feature is usually required whenever an ISDN call originates in, is destined for, or passes through the U.S., where 56 Kbps ISDN connections are not uncommon.

ISDN Equipment Configurations

In a BRI configuration, an ISDN adapter, also known as a Terminal Adapter (TE), connects directly to NT1 network terminating equipment. This device is provided by a service provider except in North America where users must supply their own NT1 or order a BRI U-interface NIM with a built-in NT1.

The NT1 delimits between U and S/T reference points. The U reference point represents the last section of the network that connects the Central Office with a customer's premises while the S/T

reference point represents the customer premises' wiring. S/T is a point-to-multipoint wiring configuration, that is, the NTI can be connected to as many as eight TEs that contend for the two B channels. Most XSR applications are critical and require point-to-point connections with the ISDN service to ensure that the B channels are available in a timely fashion. International users are limited to ordering the S/T NIM as it is the only approved device for connection to the network. North American users can order U or S/T NIMs depending on wiring premises' requirements.

Bandwidth Optimization

The XSR offers features which reduce call connection time and prevent network overhead from triggering ISDN calls.

- *Dial-on-Demand* (DoD) processes data calls strictly as needed, when interesting packets must be passed to specific destinations.
- *Bandwidth-on-Demand* (BoD) allocates ISDN bandwidth as efficiently as possible to accommodate varying traffic loads. The first element of this feature set is *short-hold* mode, which prevents links from forming in the absence of data traffic, while simulating continuous connections.

For instance, suppose a remote workstation was connected to the corporate LAN via ISDN, but no data was being sent because a user's PC was idle. With short-hold mode, in the absence of any data traffic the ISDN call would be brought down, although from the user's perspective the link/route would still be active, since any data transfer would automatically (and transparently) bring up an ISDN call.

The second element of BoD directs that as traffic requirements increase or decrease, B-channels can be added or subtracted to best accommodate the load. This dynamic form of channel aggregation is often used by Multilink PPP which aggregates channels across multiple B channels of one or more BRI/PRI ports. The XSR implements this element of BoD with the **`multilink load-threshold`**, **`multilink min-links`**, and **`bap`** set of commands.

To further make BoD work properly, the XSR also implements filtering and protocol spoofing in order to prevent network overhead such as RIP updates from needlessly bringing up the ISDN link. Although some of these frames can be discarded without any negative consequences, most are required to keep workstations and servers across the entire enterprise network synchronized with one another.

The XSR filters unnecessary overhead by the use of Access Control Lists specifying interesting packets, and by *spoofing* protocol overhead packets to maintain the routes while keeping ISDN connection costs under control.

The XSR performs LAN spoofing where on demand calls spoof RIP or OSPF updates - RIP updates are sent over the WAN only when changes to the network occur and are *piggy-backed* with data traffic. The **`dialer map command`** is used to enable spoofing.

Security

Security is another important element of dial-up data communications, and ISDN can support the security features of protocols running through it, as well as its own unique mechanisms. ISDN, in addition to supporting the standard authentication schemes of protocols riding on it (e.g. PPP's PAP/CHAP protocols), enhances the security of dial-up connections with call number ID.

With support for call number identification invoked by the **`isdn calling-number`** command, the XSR enables the comparison of incoming callers' phone numbers with a list of acceptable numbers. Calls can then be restricted to pre-screened locations, a definite advantage especially when PAP/CHAP authentication is unavailable.

Call Monitoring

Call monitoring is also an vital element of the XSR's ISDN service. Call monitoring features are useful in terms of security, but also enable tracking of call volume and logging of all connections so that administrators can optimize the number of ISDN lines ordered. Given that ISDN costs are often usage-related, this checking and recording also can prevent nasty surprises that users might receive with the monthly phone bill. At the same time, usage logs can provide managers with the justification required to add ISDN lines as the need for additional bandwidth arises.

The **`show interface bri`**, **`show controllers bri`**, and **`show isdn service`** commands display virtual and physical line attributes including B channel idle warnings.

The **`show isdn history`** and **`show isdn active`** commands display Cause Codes giving the reason why a call was disconnected. These codes are detailed in Table 11-2 on page 11-16.

ISDN Trace

The XSR supports protocol tracing and partial decoding of Q921 and Q931 frames for ISDN troubleshooting with the **`debug isdn`** command. This command initiates a Layer 2 (link) or Layer 3 (call data) ISDN debug session to trace failed calls at the D channel level. Issuing the command has the effect of locking out debugging by any other current Telnet or Console connection. If you select both Layer 2 (Q921) and 3 (Q931), tracing will display both layers.

Note: Users with privilege *level 15* only can issue this command.

You can exit the debug session either by issuing the **`no debug isdn`** command or terminating the Telnet session. As an option, you can set a limit of up to 9999 messages which will display at the CLI after which the debug session will end. If the limit is not specified, after 100 displayed messages, the **`no debug isdn`** command will automatically run. The limit parameter is a global value that is refreshed each time **`debug isdn`** is entered.

Trace Decoding

The XSR captures Q931 and Q921 packets in binary format from the D channel, decodes and displays them. Partial decoding is performed on the most frequent *messages* and *information elements (IEs)*, with the undecoded section of the packets displayed in hexadecimal format. Be aware that if you require full decoding, you should use an ISDN logical analyzer.

All ISDN protocol trace lines comprise the following common fields:

- *Rx/Tx* shows a message received or transmitted by the XSR
- *ISDN-BRI/ISDN-PRI* indicates the type of line monitored and XSR slot and card numbers
- *slot/card/port* identifies the monitored port
- *hh:mm:ss:msec* displays the time stamp

Q921 Decoding

At Q921 Layer 2, the XSR decodes all Link Access Protocol - D Channel (LAPD) frames up to octet 5 of the message - the header. Q931 call information - the data in UI and INFO frames - is displayed in hex on the second line, as shown in two of the following examples. Reference codes are described in the succeeding section:

- + 1st line:

```
Rx ISDN-BRI 1/0 03:13:47:676 Q921 UI p 0 sapi 63 tei 127 c/r 1
```

- \+ 2nd line:

```
info:0F 00 00 06 FF

Tx ISDN-BRI 1/0 03:13:52:601 Q921 INFO p 0 nr 0 ns 0 sapi 0 tei 64 c/r0
info:08 00 7B 3A 07 32 38 30 30 35 35 35

Tx ISDN-BRI 1/0 03:13:52:556 Q921 SABME p 1 sapi 0 tei 64 c/r 0

Rx ISDN-BRI 1/0 03:13:52:661 Q921 RR p/f 0 nr 1 sapi 0 tei 64 c/r 0
```

Reference Parameters

UI - Unnumbered Information.

SABME - Set Asynchronous Balanced Mode Extender.

c/r - Command/Response field bit.

SAPI - Service Access Point Identifier.

TEI - Terminal Endpoint Identifier.

Ua - Unnumbered acknowledgement.

nr - Receive Sequence Number.

ns - Send Sequence Number.

INFO - Q931 Information message.

RR - Receive Ready

Note: For a complete list of reference codes, see: http://www.atis.org/tg2k/

Q931 Decoding

At Q931 Layer 3, the XSR partially decodes Q931 messages as follows:

- On line 1 after the *time stamp* field, the *call reference* and *message type* displays.
- On line 2, the complete *hexadecimal dump* of the message is shown.
- On the following lines the IEs, if any, display as follows:
  - Hexadecimal code of the IE
  - Name of the IE
  - Hexadecimal dump of the IE or further decoding

Refer to the following Q931 example:

- \+ 1st line:

```
Tx ISDN-BRI 1/0 03:32:48:203 CallRef=7 SETUP
```

- \+ 2nd line:

```
00 81 12 0E 08 01 07 05 04 02 88 90 18 01 81 6C 06 00
   80 32 38 30 30 70 05 80 32 35 30 30
```

– + Next line: 04 Bearer capability 8890

```
18 Channel Id. 81
6C Calling number N0:2800
70 Called number N0:2500
```

The succeeding section lists all message types and IEs the XSR displays. All unsupported message types and IEs are marked *UNKNOWN* or *IE not Found*.

Table 11-1 Q931 Decoding

Message #	Message Type	IE #	Information Element
0x00	NATIONAL	0xA1	Sending complete
0x01	ALERT	0xA0	More Data
0x02	CALL PROC	0x04	Bearer capability
0x07	CONNECT	0x08	Cause
0x0f	CONNECT ACK	0x10	Call identity
0x03	PROGRESS	0x14	Call state
0x05	SETUP	0x18	Channel Id.
0x0d	SETUP ACK	0x1C	Facility
0x23	MODIFY	0x1E	Progress indicator
0x2f	MODIFY COMP	0x20	Net specific facility
0x23	MODIFY REJ	0x27	Notification indicator
0x26	RESUME	0x28	Display
0x2e	RESUME ACK	0x29	Date/time
0x22	RESUME REJ	0x2C	Keypad facility
0x25	SUSPEND	0x34	Signal
0x2d	SUSPEND ACK	0x36	Switch hook
0x21	SUSPEND REJ	0x38	Feature activation
0x20	USER INFO	0x39	Feature indication
0x45	DISCONNECT	0x40	Information rate
0x4d	RELEASE	0x42	End-to-end transit delay
0x5a	RELEASE COMPL	0x6C	Calling number
0x46	RESTART	0x6D	Calling subaddress
0x4e	RESTART ACK	0x70	Called number
0x60	SEGMENT	0x71	Called subaddress
0x79	CONGESTION	0x74	Redirecting number
0x7b	INFO	0x78	Transit Network
0x62	FACILITY	0x79	Restart indicator
0x6e	NOTIFY	0x7C	Low layer compatibility
0x7d	STATUS	0x7D	High layer compatibility

Table 11-1 Q931 Decoding

Message #	Message Type	IE #	Information Element
0x75	STATUS ENQ	0x7E	User-user
0xFF	UNKNOWN	0x7F	escape for extension

Decoded IEs

Only IEs referring to *data calls* are supported and decoded by the XSR, as shown in the following examples. Those IEs used for voice calls and supplementary services are not applicable.

- Called party number:

```
70 Called number N0:2500
```

- Calling party number:

```
6C Calling number N0:2800
```

- Cause:

```
08 Cause 8090 Normal clearing.
```

Refer to "ISDN (ITU Standard Q.931) Call Status Cause Codes" on page 11-16 for a list of all supported cause codes.

BRI NI-1, DMS100 & 5ESS SPID Registration

For registration purposes, Q931 "dummy" messages (with call reference number 0) are supported, as shown in the following example:

```
Tx ISDN-BRI 1/0 03:33:39:603 CallRef=Dummy INFO
00 81 00 00 08 00 7B 3A 07 32 38 30 30 35 35 35
        3A Service Profile ID 32383030353535
Rx ISDN-BRI 1/0 03:33:39:688 CallRef=Dummy INFO
02 81 00 02 08 00 7B 3B 02 8F B7
        3B End Point Identifier 8FB7
```

Terminal Endpoint Identifier (TEI) Management Procedures

TEI management frames display as UI frames as illustrated in the following examples:

```
Rx ISDN-BRI 1/0 04:01:16:242 Q921 UI p 0 sapi 63 tei 127 c/r 1
info:0F 00 00 06 FF
#
Tx ISDN-BRI 1/0 04:01:21:091 Q921 UI p 0 sapi 63 tei 127 c/r 0
info:0F 42 56 01 FF
```

ISDN Configuration

PRI interfaces share the T1/E1 NIM card and all physical configuration values the controller can configure. The **`pri-group`** command assigns the channels (DS0s) of the T1/E1 port to ISDN module control. Interfaces are configured one of two ways using the following commands:

- The **`pri-group`** command ISDN switching.

- The **channel-group** command for point-to-point connections.

The above commands are mutually *exclusive*: you can enter one or the other per PRI interface, not both. On the E1 NIM, 30 channels are controlled by ISDN, and 23 channels on the T1 NIM. Other PRI commands include:

- **bchan-number-order** selects a channel from B1 (ascending) or B23/B32 (descending).
- **calling-number** configures an outgoing ISDN calling number.
- **switch-type** specifies the Central Office ISDN switch type.

BRI interfaces utilize a BRI-S/T or UNIM card. From a software perspective, S/T and U cards are equivalent and all features supported on both cards are equivalent. The card type is significant during installation only. In North America, the U card is connected directly to the ISDN service jack, the S/T card requires an external NT1 device to be connected between the S/T card and the service jack. Outside North America, only the S/T card is used with very few exceptions.

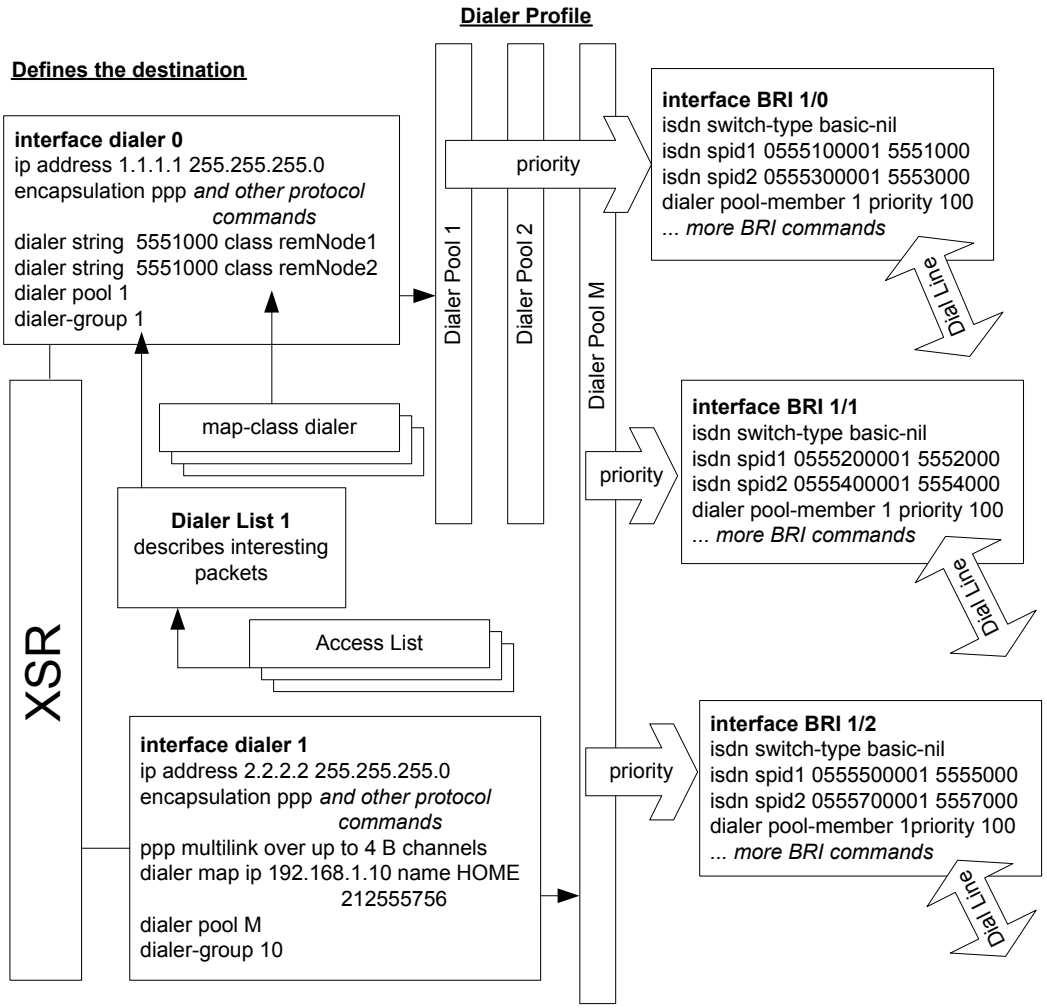
The two basic modes of operation of the BRI card are: *CMD* switched mode and *leased line* (permanent) mode. Leased line mode is configured similar to T1/E1 channelized operation mode - commands are entered at Controller configuration mode. BRI ISDN commands include:

- **answer1/2** adds a called *number:subaddress* to be screened.
- **calling-number** adds a calling number included in outgoing calls.
- **spid1/2** sets a Service Profile ID string *calling-number: subaddress.*
- **switch-type** selects the interface ISDN switch type.
- **leased-line** sets a BRI interface to support leased lines.

BRI (Switched) Configuration Model

Figure 11-1, shown below, illustrates how Dialer and BRI interfaces are configured on the XSR's BRI NIM card (XSR 1800/3000 Series) as well as how those interfaces correlate to dialer and access lists, map classes, and dialer pools

Figure 11-1 .Switched BRI Configuration Model



The following example adds a dialer pool and group, and two phone numbers to the called node's Dialer 0 port. It also configures a second dialer pool and group, a Multilink PPP line to four B channels on the Dialer 1 interface, and maps the 192.168.1.10 network and phone number to BRI interface 1/0, as well as adds a prioritized pool member and six SPIDs. Finally, the example configures two more BRI interfaces with prioritized pool members and two SPIDs each. You can add map class, dialer and access list, BRI, and other protocol commands not shown in the example.

Note: ISDN BRI can be configured on XSR 1200 Series routers but only on interface **`FastEthernet 0:<1-2>.<1-30>`**. All BRI examples in this chapter reference Ethernet interfaces on XSR 1800/3000 Series routers.

```
XSR(config)#interface dialer 0
XSR(config-if<D0>)#ip address 1.1.1.1 255.255.255.0
XSR(config-if<D0>)#encapsulation ppp
XSR(config-if<D0>)#dialer string 5551000 class remNode1
XSR(config-if<D0>)#dialer string 5551000 class remNode2
XSR(config-if<D0>)#dialer pool 1
XSR(config-if<D0>)#dialer-group 1
XSR(config-if<D0>)#no shutdown
```

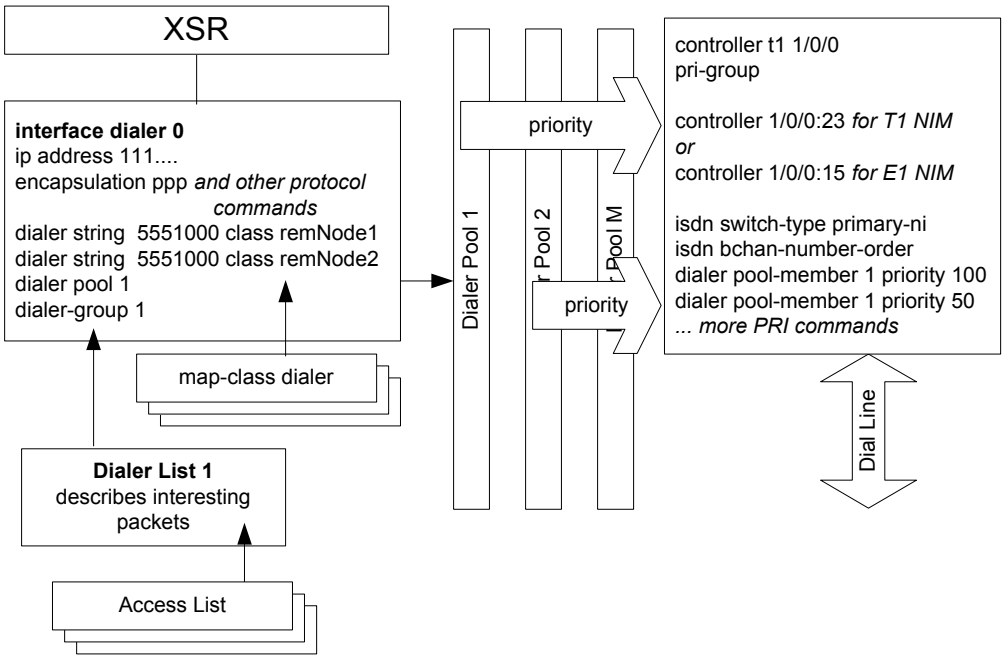
```
XSR(config)#interface dialer 1
XSR(config-if<D1>)#ip address 2.2.2.2 255.255.255.0
XSR(config-if<D0>)#encapsulation ppp
XSR(config-if<D0>)#ppp multilink
XSR(config-if<D0>)#dialer map ip 192.168.1.10 name HOME 212555756
XSR(config-if<D0>)#dialer pool M
XSR(config-if<D0>)#dialer-group 10
XSR(config-if<D0>)#no shutdown
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#isdn switch-type basic-ni1
XSR(config-if<BRI-1/0>)#isdn spid1 0555100001 5551000
XSR(config-if<BRI-1/0>)#isdn spid2 0555300001 5553000
XSR(config-if<BRI-1/0>)#dialer pool-member 1 priority 100
XSR(config-if<BRI-1/0>)#no shutdown
XSR(config)#interface bri 1/1
XSR(config-if<BRI-1/1>)#isdn switch-type basic-ni1
XSR(config-if<BRI-1/1>)#isdn spid1 0555200001 5552000
XSR(config-if<BRI-1/1>)#isdn spid2 0555400001 5554000
XSR(config-if<BRI-1/1>)#dialer pool-member 1 priority 90
XSR(config-if<BRI-1/1>)#no shutdown
XSR(config)#interface bri 1/2
XSR(config-if<BRI-1/2>)#isdn switch-type basic-ni1
XSR(config-if<BRI-1/2>)#isdn spid1 0555500001 5555000
XSR(config-if<BRI-1/2>)#isdn spid2 0555700001 5557000
XSR(config-if<BRI-1/2>)#dialer pool-member 1 priority 80
XSR(config-if<BRI-1/2>)#no shutdown
```

For further explanation and more examples of Dialer interface and Multilink PPP configuration, refer to "Configuring Dialer Services" on page 10-1 and "Configuring PPP" on page 8-1.

PRI Configuration Model

Figure 11-2, shown below, configures Dialer and Serial interfaces on the XSR's PRI NIM card (XSR 1800/3000 Series only) as well as describes how those interfaces correlate to dialer and access lists, map classes, dialer pools, and channel groups

Figure 11-2 .PRI Configuration Model



The following T1 example configures the interface for ISDN PRI operation, adds a dialer pool and group, and one dialer string to the node's Dialer 1 port. The ISDN PRI interface belongs to two prioritized pool members. You can add map class, dialer list and ACL commands not shown.

The **pri-group** command enables ISDN and configures all timeslots to map to channel groups on the PRI NIM card: for a T1 NIM, 23 B and one D channel, for an E1 NIM, 30 B and one D channel.

```
XSR(config)#interface dialer 1
XSR(config-if<D0>)#ip address 1.1.1.1 255.255.255.0
XSR(config-if<D0>)#encapsulation ppp
XSR(config-if<D0>)#dialer string 17574231234 class rem node1
XSR(config-if<D0>)#dialer pool 1
XSR(config-if<D0>)#dialer-group 1
XSR(config-if<D0>)#no shutdown

XSR(config)#controller t1 1/0/0
XSR(config-controller<T1-1/0/0>)#pri-group
XSR(config-controller<T1-1/0/0>)#isdn switch-type primary-ni
XSR(config-controller<T1-1/0/0>)#isdn bchan-number-order ascending
XSR(config-controller<T1-1/0/0>)#dialer pool-member 1 priority 100
XSR(config-controller<T1-1/0/0>)#dialer pool-member 2 priority 50
XSR(config-controller<T1-1/0/0>)#no shutdown
```

Optionally, the following *E1* commands set the Central Office switch type and add prioritized pool members to E1 1/0/0:15 D-channel sub-interface:

```
XSR(config)#controller e1 1/0
XSR(config-controller<E1-1/0>)#isdn switch-type primary-net5
XSR(config-controller<E1-1/0>)#isdn bchan-number-order ascending
XSR(config-controller<E1-1/0>)#no shutdown
XSR(config-controller<S1-1/0>)#dialer pool-member 1 priority 100
XSR(config-controller<S1-1/0>)#dialer pool-member 2 priority 50
```

Be aware that the **`isdn bchan-number-order`** command forces the PRI interface to make outgoing calls in ascending or descending order. The command is recommended only if your service provider requests it to lessen the chance of call collisions.

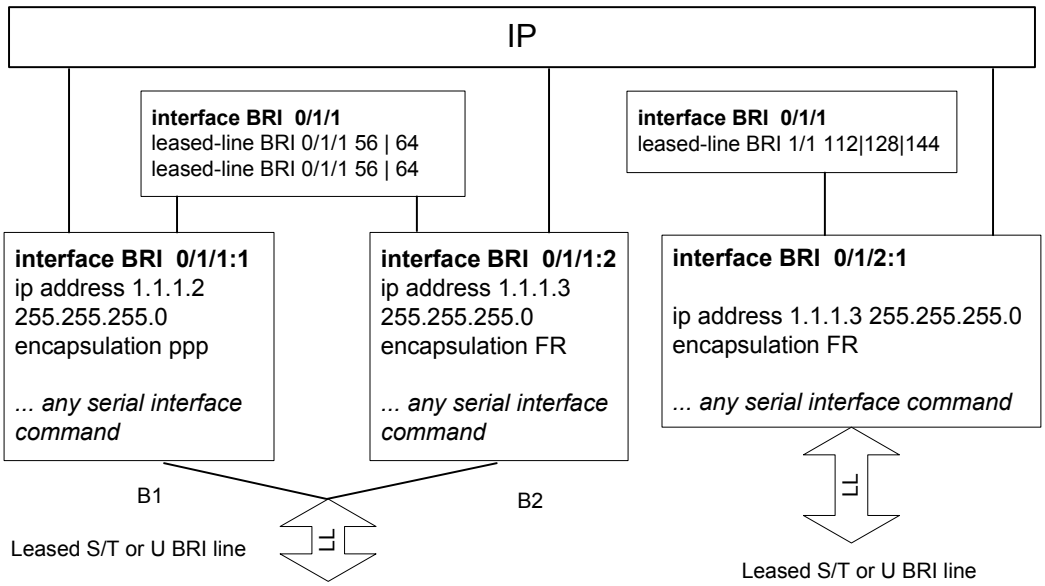
Leased-Line Configuration Model

The BRI Leased Line application supports two basic modes: *each* B channel is routed to a different destination or *both* B channels are bounded. Only one BRI-specific command is needed for this application, **`leased-line`**, which can be configured at 56, 64, 112, 128, or 144 Kbps.

Note: Be aware that two data streams are supported, one on each B channel, at 56 and 64 Kbps only, and one data stream is supported over the bounded B1 + B2 or B1+B2+D line at 112, 128, or 144 Kbps only.

Figure 11-3 illustrates how a Leased Line application is configured on the XSR's BRI NIM card (XSR 1800/3000 Series) with either PPP or Frame Relay encapsulation.

Figure 11-3 BRI Leased Line Application



The following commands, as shown in Figure 11-3, add two leased lines on BRI 0//1/1 B-channels 1 and 2 with PPP and Frame Relay encapsulation on either line. You can add other serial interface commands as needed..

Note: ISDN BRI can be configured on XSR 1200 Series routers but only on interface **`BRI 0:<1-2>.<1-30>`**. All BRI examples in this chapter reference Ethernet interfaces on XSR 1800/3000 Series routers.

```
XSR(config)#interface bri 0/1/1
XSR(config-if<BRI-1/1>)#leased-line bri 0/1/1 56
XSR(config-if<BRI-1/1>)#leased-line bri 0/1/1 56
XSR(config-if<BRI-1/1>)#no shutdown
XSR(config)#interface bri 0/1/1:1
XSR(config-if<BRI-1/1:1>)#ip address 1.1.1.2 255.255.255.0
XSR(config-if<BRI-1/1:1>)#encapsulation ppp
XSR(config-if<BRI-1/1:1>)#no shutdown
XSR(config)#interface bri 0/1/1:2
```

```
XSR(config-if<BRI-1/1:2>)#ip address 1.1.1.3 255.255.255.0
XSR(config-if<BRI-1/1:2>)#encapsulation frame relay
```

The following commands add a third, *bundled* B1/B2 line on BRI interface 0/1/1 and another lease line on BRI channel 0/1/2:1 with Frame Relay encapsulation. You can add other serial interface commands as needed.

```
XSR(config)#interface bri 0/1/1
XSR(config-if<BRI-1/1>)#leased-line bri 0/1/1 144
XSR(config-if<BRI-1/1>)#no shutdown
XSR(config-if)#interface bri 0/1/2:1
XSR(config-if<BRI-0/1/2:1>)#ip address 1.1.1.3 255.255.255.0
XSR(config-if<BRI-0/1/2:1>)#encapsulation frame relay
```

More Configuration Examples

The following configuration examples cover T1/E1, PRI and BRI, and lease-line options on the XSR. For more details on Dialer and Multilink PPP options, refer to "Configuring Dialer Services" on page 10-1 and "Configuring PPP" on page 8-1..

Note: ISDN BRI can be configured on XSR 1200 Series routers but only on interface **`FastEthernet 0:<1-2>.<1-30>`**. All BRI examples in this chapter reference Ethernet interfaces on XSR 1800/3000 Series routers.

T1 PRI

The following example configures a PRI connection on a T1 card:

```
XSR(config)#controller t1 1/2/3
XSR(config-controller<T1-2/3>)#pri-group
XSR(config-controller<T1-2/3>)#isdn switch-type primary-ni
XSR(config-controller<T1-2/3>)#isdn bchan-number-order descending
XSR(config-controller<T1-2/3>)#isdn calling-number 915086671234
XSR(config-controller<T1-2/3>)#no shutdown
```

E1 PRI

The following example configures a PRI connection on an E1 card:

```
XSR(config)#controller e1 1/2/2
XSR(config-controller<E1-2/2>)#pri-group
XSR(config-controller<E1-2/2>)#isdn switch-type primary-net5
XSR(config-controller<E1-2/2>)#isdn bchan-number-order descending
XSR(config-controller<E1-2/2>)#isdn no calling-number
XSR(config-controller<E1-2/2>)#no shutdown
```

ISDN BRI

The following example configures a switched line BRI connection:

```
XSR(config)#interface bri 1/1
XSR(config-if<BRI-1/1>)#isdn switch-type basic-ni1
XSR(config-if<BRI-1/1>)#isdn spid1 2200555 2200
XSR(config-if<BRI-1/1>)#isdn spid2 2201555 2201
```

```
XSR(config-if<BRI-1/1>)#no shutdown
XSR(config-if<BRI-1/1>)#dialer pool-member 1 priority 1
```

BRI Leased Line

The following example configures a leased-line BRI connection:

```
XSR(config)#interface bri 1/0
XSR(config-if<BRI-1/0>)#leased-line 64
XSR(config-if<BRI-1/0>)#leased-line 64
XSR(config-if<BRI-1/0>)#no shutdown
```

BRI Leased PPP

The following example configures a leased PPP connection on a BRI link:

```
XSR(config)#interface bri 1/0:2
XSR(config-if<BRI-1/0:2>)#no shutdown
XSR(config-if<BRI-1/0:2>)#encapsulation ppp
XSR(config-if<BRI-1/0:2>)#ip address 10.10.10.11 255.255.255.0
XSR(config-if<BRI-1/0:2>)#ppp keepalive
```

BRI Leased Frame Relay

The following example configures Frame Relay service over a multipoint leased BRI connection. For more information on Frame Relay, refer to "Configuring Frame Relay" on page 9-1.

```
XSR(config)#interface bri 1/0:1
XSR(config-if<BRI-1/0:1>)#no shutdown
XSR(config-if<BRI-1/0:1>)#encapsulation frame-relay
XSR(config-if<BRI-1/0:1>)#frame-relay lmi-type none
XSR(config)#interface bri 1/0:1.1 multi-point
XSR(config-if<BRI-1/0:1>)#ip address 2.2.2.2 255.255.255.0
XSR(config-if<BRI-1/0:1>)#frame-relay interface-dlci 16
XSR(config-if<BRI-1/0:1-16>)#no shutdown
```

ISDN (ITU Standard Q.931) Call Status Cause Codes

The XSR supports the Q.931 cause codes shown in the table below. Those codes marked with an asterisk (*) are decoded into text by ISDN debugging. All other codes display a plus sign (+).

Table 11-2 Call Status Cause Codes

Code	Cause
0	Valid cause code not yet received
1	Unallocated (unassigned) number
2	No route to specified transit network (WAN)
3	No route to destination
4	Send special information tone/Channel unacceptable
5	Misdialed trunk prefix
6	Channel unacceptable

Table 11-2 Call Status Cause Codes (continued)

Code	Cause
7	Call awarded and being delivered in an established channel
8	Prefix 0 dialed but not allowed
9	Prefix 1 dialed but not allowed
10	Prefix 1 dialed but not required
11	More digits received than allowed, call is proceeding
16*	Normal call clearing
17*	User busy
18*	No user responding
19*	No answer from user
21*	Call rejected
22*	Number changed
23*	Reverse charging rejected
24*	Call suspended
25*	Call resumed
26	Non-selected user clearing
27*	Destination out of order
28*	Invalid number format (incomplete number)
29*	Facility rejected
30*	Response to STATUS ENQUIRY
31*	Normal, unspecified
33*	Circuit out of order
34*	No circuit/channel available
35*	Destination unattainable
36*	Out of order
37*	Degraded service
38*	Network (WAN) out of order
39	Transit delay range cannot be achieved
40	Throughput range cannot be achieved
41*	Temporary failure
42*	Equipment congested
43*	Access information discarded
44*	Requested circuit channel unavailable
45	Pre-empted
46	Precedence call blocked
47*	Resource unavailable - unspecified
49	Quality of service unavailable
50	Requested facility not subscribed
51	Reverse charging not allowed
52	Outgoing calls barred
53	Outgoing calls barred within CUG

Table 11-2 Call Status Cause Codes (continued)

Code	Cause
54	Incoming calls barred
55	Incoming calls barred within CUG
56	Call waiting not subscribed
57	Bearer capability not authorized
58	Bearer capability not presently available
63	Service or option not available, unspecified
65	Bearer service not implemented
66	Channel type not implemented
67	Transit network selection not implemented
68	Message not implemented
69	Requested facility not implemented
70	Only restricted digital information bearer capability is available
79	Service or option not implemented, unspecified
81	Invalid call reference value
82	Identified channel does not exist
83	A suspended call exists, but this call identity does not
84	Call identity in use
85	No call suspended
86	Call having the requested call identity has been cleared
87	Called user not member of CUG
88	Incompatible destination
89	Non-existent abbreviated address entry
90	Destination address missing, and direct call not subscribed
91	Invalid transit network selection (national use)
92	Invalid facility parameter Mandatory information element is missing
95	Invalid message, unspecified
96	Mandatory information element is missing
97	Message type non-existent or not implemented
98	Message incompatible with call state, message type non-existent or not implemented
99	Information element nonexistent or not implemented
100	Invalid information element contents
101	Message not compatible with call state
102	Recovery on timer expiry
103	Parameter non-existent or not implemented - passed on
111	Protocol error, unspecified
127	Internetworking, unspecified

12

Configuring Quality of Service

Overview

In a typical network, there are often many users and applications competing for limited system and network resources. While resource sharing on a first-come, first-serve basis may suffice when your network load is light, access can freeze quickly when the network gets congested. Under these conditions, a bandwidth-hungry application (large file transfer files, emails) may devour most of the network bandwidth, depriving applications that send small-sized packets (voice, telnet and other interactive applications) of their fair share of bandwidth, and result in long delays causing applications to fail.

Quality of Service (QoS) cannot magically provide all applications their requested bandwidth, but it can help you identify your mission-critical, high priority application traffic and give it preferential treatment (higher priority, higher bandwidth or guaranteed bandwidth) relative to the rest of your network traffic. In this way, critical applications will work under both normal and congested conditions while less important and time-sensitive traffic will continue to flow, perhaps at a lower rate than expected.

Consider the following aspects of the XSR's QoS implementation:

- QoS can be configured on LAN and/or WAN interfaces/sub-interfaces.
- QoS is implemented as a service which can be applied on any interface at will (intuitive configuration).
- Packet *classification* is based on source/destination address, source/destination port, IP precedence or DSCP value and is specified using ACLs, the IP precedence or DHCP fields.
- *Class-Based queuing* is provided for prioritization and bandwidth sharing.
- Up to four *priority queues* and 60 *shared queues* can be configured per policy-map.
- *Link efficiency* mechanisms with *interleaving* for real-time traffic: *Multi Class MLPPP* for PPP and *FRF.12* for Frame Relay.
- Traffic *policing* using Single-color, Three-rate token bucket.
- Three buffer management strategies: *tail drop*, *Weighted* and *Random Early Detection* (WRED/RED).
- Traffic *shaping* per class and per policy map on the *output* traffic.
- Marking the *DSCP* or *IP precedence field* of the packet.
- Marking the *802.1P* info in VLAN header.
- *Service policy* can be applied on the *input* and/or *output* traffic.
- Automatic internal prioritization of the control packets locally generated by the XSR.

- QoS on the dialer interfaces is directly applied to the dialer interface and inherited by the dial pool members (Serial or ISDN).
- QoS on *MLPPP* interfaces.
- QoS on point-to-point and point-to-multi-point *VPN* interfaces.
- Control over *copy of the ToS byte* from/to outer header for VPN tunnels.
- QoS on *Ethernet* port and sub-interfaces (PPPoE and VLAN).

Be aware that QoS service on the XSR is proscribed by the following limits:

- No more than 64 classes permitted
- Traffic policer cannot be set for traffic flows assigned to priority queues. Each priority queue is metered and policed by default to guarantee it conforms to the scheduled traffic pattern
- **`Priority`** and **`bandwidth`** commands are mutually exclusive; a traffic flow is assigned to either queue, not both
- Tail-drop (**`queue-limit`**) and RED (**`random-detect`**) are mutually exclusive; a queue is managed by either mechanism, not both
- QoS on Input does not perform the following: packet buffering, shaping, bandwidth sharing, prioritization, CoS bit marking in the VLAN header, RED or WRED

Mechanisms Providing QoS

This section describes the general mechanisms the XSR employs to support Quality of Service.

Traffic Classification

Before the XSR can apply QoS to traffic, it must differentiate between types of traffic. The process is called traffic classification. Table 12-1 on page 12-2 describes typical traffic classification:

Table 12-1 Traffic Classification

Classification Criteria	Description	Additional Comments
IP Precedence bits in IP header (IP only)	Simple classification for IP packets only. IP Precedence bits reside in the ToS byte of the IPv4 header and are 3-bits long, providing up to 8 levels of QoS classes.	Simple, IP traffic only
DSCP (DiffServ Code Point) bits in IP header (IP only)	Simple classification for IP packets only. This QoS signaling method is defined by the IETF DiffServ group providing a scalable QoS solution. It is 6-bits long and can provide 64 different traffic classes. DSCP overlaps with the IP Precedence bits in the IP header and can be considered a super set of IP Precedence.	Simple, IP traffic only
Multiple-Field Classification	This classification considers the L3 header (source and destination IP addresses), L4 header (TCP/UDP port numbers to identify the nature of applications as FTP, Telnet, Web, etc.), and in some cases, looks at fields beyond the L4 header (e.g., to differentiate Web access to certain Web pages from other Web accesses), to narrow the classification and choose traffic from a particular application.	Most versatile but CPU intensive

The XSR provides a class-based traffic classifier that creates traffic policies and attaches them to interfaces, sub-interfaces, and virtual circuits such as Frame Relay DLCIs. A traffic *policy* contains a traffic *class* and one or more QoS features. A traffic *class* is used to classify traffic, while the QoS

features in the traffic policy determine how to treat the classified traffic. Traffic policy cannot be applied to multilink PPP interfaces at this time.

Note: A Dialer interface is similar to a virtual interface in that only after it dials on a resource from a dialer pool is it able to receive and send data. A policy map applied to a dialer interface is automatically pushed to the resource (Serial or ISDN interface) that the dialer called on. When the connection is cleared, the policy map is automatically removed from the resource.

You must perform three steps to configure a class-based classifier:

1. Define a traffic class with the **`class-map`** command.
2. Create a traffic policy by associating the traffic class with one or more QoS features (using the **`policy-map`** command).
3. Attach the traffic policy to the port or DLCI with the **`service-policy`** command.

A QoS policy-map for DLCI defines a set of complex rules to identify classes of traffic and then applies service policies to them. Use the traffic-class-map to group a set of simple rules to form a set of complex rules. You can define complex rules with a combination of matching criteria and, at the same time, not matching other criteria.

Describing the Class Map

The traffic class map builds complex rules with matching criteria. Multiple rules can be specified by a given traffic class-map using the **`class-map`** command, but all rules in the given class map must be configured to use the same matching criteria:

- match-any
- match-all

The following traffic class map defines the match-all class-map *abc*. A packet that satisfies the criteria defined in access-group 2 and has a DSCP value set to 32 is considered a part of this traffic class. In a match-all class-map all criteria must be met in order for the packet to be assigned to the class.

```
XSR(config)#access-list 2 permit 15.15.15.0 0.0.0.255
XSR(config)#class-map match-all abc
XSR(config-cmap<abc>)#match access-group 2
XSR(config-cmap<abc>)#match ip dscp 32
```

In a *match-any* class-map, one or more criteria of the class-map must be met in order for packets to be assigned to the class. For example, if class-map *ABC* were a match-any class-map, packets arriving with a source address of 15.15.15.3, with Layer 3 protocol IP and DSCP value of 12 assigned, would be classified as class *ABC* since it matches access-list 2.

Describing the Policy Map

The policy statement in a QoS policy-map specifies how traffic defined by the traffic class-map will be treated. Each class in policy-map has to be assigned to one of the two types of queues: CBWFQ or Priority Queue. This includes specifying the following:

- The **`bandwidth`** command assigns traffic from this class to a Class- Based Weight Fair Queue (CBWFQ) with the specified bandwidth. A CBWFQ shares the output link with other CBWFQs on the same link in proportion to its specified bandwidth or weight. During congestion, queues are serviced (assigned bandwidth) in proportion to their weight. When uncongested, a queue can borrow bandwidth from other queues.

- The **priority** command assigns traffic from this class a Priority Queue (PQ) and sets the parameter for the queue. Priority queues provide guaranteed bandwidth - they always receive the bandwidth requested. Priority class is not allowed to send more than its guaranteed bandwidth and excess traffic is discarded. Unused priority bandwidth is picked up by the *class-default* class.

For classes that are assigned to CBWFQ you can control the maximum rate of traffic sent or received on a port as follows:

- The **police** command controls traffic received by a queue by defining the action taken for packets that conform or exceed the specified rate. You may drop the packet, change its IP precedence or DSCP setting, or forward it without modification.

Both CBWFQ and Priority Queues can control queue size and the type of congestion avoidance mechanism, as well as mark packets as follows:

- The **set ip precedence**, **set ip dscp** commands mark a packet by setting the IP precedence or DSCP field. The Differentiated Services Field is defined in RFCs-2474 and 2475.
- The **queue-limit** command specifies or modifies the maximum number of packets the queue can hold before tail drop for TCP/IP traffic for a class policy configured in a policy map.
- The **random-detect** command sets Random Early Detect (RED), a congestion avoidance mechanism that slows traffic by randomly dropping packets when congestion exists.

Traffic not assigned to a class in the policy map is assigned to *class-default* which is present by default and assigned as a CBWFQ. Bandwidth for the *class-default* comprises whatever remains after all other classes are served. You can configure *class-default* as any other CBWFQ, except that you cannot assign bandwidth to it.

Queuing and Services

Once traffic has been classified, it is dropped into different queues so that each class of traffic can be treated differently (priority, bandwidth etc.). The following describes two queue types used in the XSR: Class Based Weight Fair Queuing and Priority Queuing. They are mutually exclusive - only one type of queue may be applied to one class. But, they may be mixed in a policy-map when applied to different classes.

Describing Class-Based Weight Fair Queuing

The configured bandwidth of a class is the bandwidth delivered to the class during congestion. The higher the bandwidth, the more likely the packet is being transmitted under congested conditions. If there is no data on a particular queue, then its share of the bandwidth will be divided and shared among the active queues in proportion to their specified bandwidth.

CBWFQ specifies the exact amount of bandwidth to allocate for a specific class, or queue, of traffic. Taking into account available bandwidth on the interface, you can configure up to 64 classes and control distribution among them. If excess bandwidth is available, it is divided among other CBWFQs in proportion to their configured bandwidths.

When bandwidth is specified as an absolute number, it is used to calculate the weight of the class. In such a case, the sum of bandwidth for all classes, including priority classes, should not exceed the link bandwidth otherwise the bandwidth for the default class will be zero causing a traffic blockage and packet pileup in the queue.

Note: For each policy-map, only one type of bandwidth, percentage or absolute bandwidth, can be used for all the CBWFQ classes inside the policy-map.

Configuring CBWFQ

CBWFQ is configured using the **bandwidth** command. It provides a *minimum* bandwidth guarantee during congestion. For example, policy-map *keyser* guarantees 30 percent of the bandwidth to class *sosay* and 60 percent of the bandwidth to class *intrigue*. If one class uses less of the requested share of bandwidth, the excess bandwidth may be used by the other class.

```
XSR(config)#policy-map keyser
XSR(config-pmap<keyser>)#class sosay
XSR(config-pmap-c<sosay>)#bandwidth percent 30
XSR(config-pmap<keyser>)#class intrigue
XSR(config-pmap-c<intrigue>)#bandwidth percent 60
```

Measuring Bandwidth Utilization

A quick and easy way to monitor bandwidth utilization is as follows: define an *empty* policy map, apply the policy to the serial sub-interface, and display the output of **show policy-map**. Enter the following commands:

```
XSR(config)#policy-map test
XSR(config-pmap<test>)#interface serial 1/1:0
XSR(config-subif<S1/1.0>)#service-policy output test
XSR(config-subif<S1/1.0>)#exit
XSR(config)#show policy-map interface serial 1/0:0
```

Describing Priority Queues

Priority Queues (PQ) extend absolute (strict) priority to certain traffic. Higher priority packets are sent before lower priority packets, and lower priority packets are sent before any non-priority packets. Priority queuing ensures that applications which cannot tolerate much delay (e.g., voice and video traffic) are serviced before non-time critical applications (e.g., FTP).

Traffic assigned to priority queues is rate-limited so the queue's presence would not "starve" low priority packets and fair queues. The XSR supports up to four priority queues per interface, labeled *high, medium, low,* and *normal*. They are characterized by the following rules:

- High priority queues are emptied before low priority queues.
- PQ bandwidth is controlled using a traffic policer to rate-limit it

Note: If priority queues are configured to take up almost the entire bandwidth of the interface or PVC, CBWFQ and control packets will get no actual bandwidth and may be blocked.

Configuring Priority Queues

The **priority** command configures priority queuing for certain packets based on the traffic class. When you specify priority (using the following commands) for a class, it takes a bandwidth argument affording maximum bandwidth. The following commands configure priority queuing:

- **policy-map** *policy-name*
- **class** *class-name*
- **priority** *priority-level kbps* [*burst-size*]

Be aware that bandwidth guarantees come into play when an interface is congested, at which time traffic class guarantees bandwidth equal to the specified rate. The **priority** command implements a maximum bandwidth guarantee. If the priority class does not use its bandwidth, the

excess bandwidth may be used by CBWFQ. A rule of thumb for configuring PQs is to assign time-sensitive traffic (voice and video) to PQs and other types (e.g., Telnet) to fair queues. Any traffic you do not specially assign (e.g., Email) is automatically directed to the *class-default* queue. All (100%) of your traffic should not be assigned to PQs - a smaller percentage of lower priority traffic should be designated for fair queues of left unassigned for the default queue.

Internally, the priority queue uses a Token Bucket that measures the offered load and ensures that the traffic stream conforms to the configured rate. Only traffic that conforms to the token bucket is guaranteed low latency. Any excess traffic is dropped even when the link is not congested.

The **priority** command also sets burst size, a network value used to accommodate temporary bursts of traffic. The default *burst* value, which is computed as 1 second of traffic at the configured *bandwidth* rate, is used when the *burst* argument is not specified.

The XSR allows the priority queue size to grow as much as allowed by the traffic meter.

The following example illustrates priority configuration options and how they are invoked on a Frame Relay port. Begin by creating traffic class *frost*:

```
XSR(config)#class-map frost
XSR(config-cmap<frost>)#match access-group 10
```

Assign the class *frost* to the priority queue:

```
XSR(config)#policy-map frame1
XSR(config-pmap<frame1>)#class frost
XSR(config-pmap-c<frost>)#priority high 20
XSR(config-pmap-c<frost>)#queue-limit 30
```

Describing Traffic Policing

The XSR's traffic policer lets you examine traffic flows and either *discard* or *mark* packets that exceed Service Level Agreement (SLA) Agents. Policing is most frequently used on the network border to ensure that a peer is not consuming more than its allocated bandwidth. A policer will accept traffic up to a certain rate then perform an action on traffic exceeding this rate (out-of-bound traffic). If the policer determines that the packet is *out of profile*, the packet is either dropped immediately or admitted to the network but marked as out of profile.

The XSR's implementation of traffic policing provides these benefits:

- *Per traffic class bandwidth management* permitting control of the maximum rate of traffic sent or received per traffic class.
- *Configuration of the policer using maximum rate, normal burst and excess burst.* Based on configured values, the policer separates packets into three conformance levels: packets received below the maximum rate are *conforming*, packets received as excess packets are *exceed* packets and out-of-bounds packets are *violate*.
- *Marking of packets based conformance levels.* You may specify a different action for each conforming level: *drop*, *transmit* and/or *mark* the packet. Also, you may choose to mark the *DSCP, IP precedence* or *CoS* field of the packet.

Configuring Traffic Policing

Configuring traffic policing requires creating a traffic class and attaching the policy to an interface or DLCI. The **police** command specifies the following options:

- Bandwidth, burst and excess burst values
- Action to take for traffic that conforms or exceeds the specified rate

This is how the policer works. It maintains two token buckets, one holding tokens for normal burst and the other for excess burst. The policing algorithm handles token refilling and burst checking.

Token buckets are refilled every time a new packet arrives. The specified bandwidth and the interval between the arrival time of the new packet and that of the previous packet are used to calculate the number of tokens to refill the buckets. The formula is as follows:

Refill Token Bytes equals (Bandwidth multiplied by Interval) divided by 8

The bucket for holding tokens for normal burst is refilled first. If the calculated *Refill Token Bytes* is enough to top the bucket for normal burst to the burst value specified, the remainder of *Refill Token Bytes* are added to the bucket for excess burst (refer to the formula below). Also, the number of tokens for excess burst is further limited by the excess burst value specified in the **police** command.

The packet length is checked against the token bytes available in the two buckets. If the number of token bytes in the bucket for normal burst is larger than the packet length, the *conform-action* applies to this packet; if the token bytes for normal burst is not enough, but the number of token bytes for excess burst is larger than the packet length, the *exceed-action* applies to this packet; if neither of the token bytes for normal burst or excess burst is enough, the *violate-action* applies to this packet.

In the following example, traffic policing is configured with an average rate of 8,000 bits per second, normal burst size of 2,000 bytes, and excess burst size of 4,000 bytes. Packets entering serial interface 1/0 are analyzed as to whether packets conform, exceed, or violate specified parameters. Packets which conform to parameters are sent, those which exceed parameters are set to a DSCP value of 43 and sent, and those which violate parameters are dropped.

```
XSR(config)#class-map the_heat
XSR(config-cmap<the_heat>)#match access-group 2
XSR(config)#policy-map turf
XSR(config-pmap<turf>)#class the_heat
XSR(config-pmap-c<the_heat>)#bandwidth percent 30
XSR(config-pmap-c<the_heat>)#police 8000 2000 4000 conform-action transmit
exceed-action set-dscp-transmit 43 violate-action drop
XSR(config)#interface serial 1/0
XSR(config-if<S1/0>)#service-policy output turf
```

Class-based Traffic Shaping

Routers can guarantee local performance to a connection only when that traffic is “well-behaved”. It is well established in IP networks that multiple router hops distort original traffic patterns causing an instantaneously higher rate at some routers even when the connection satisfies the client-specified rate constraint at the network entry way. Unfortunately, traffic pattern distortions due to network load fluctuations tend to accumulate in the worse case. Traffic shaping is designed to partially or completely reconstruct traffic at each router to offset this problem.

The XSR's QoS traffic shaping models traffic using token bucket. It works this way: you specify traffic characteristics using the token bucket parameters of average rate and maximum burst size. The XSR monitors output traffic and, if necessary, delays excess traffic using a buffer or queueing mechanism. Packets are stored in the queue as long as there are no available tokens in the bucket. Tokens in the bucket are supplied with the configured rate up to the maximum of the burst size. The XSR continues sending packets from the queue when it has enough tokens in the bucket. The resulting output traffic meets the required average and maximum burst rates.

Class-based traffic shaping can be configured on any class and applied to any data path (interface or DLCI) with the **shape** command. In order to do so, you must define a traffic policy and within that policy apply traffic shaping to a class. In the following example, class *ring* is shaped to 38.4 kbps, with a normal burst size of 15440 bytes.

```
XSR(config)#policy-map cbts
XSR(config-pmap<cbts>)#class ring
XSR(config-pmap-c<ring>)#shape 38400 15440
```

Traffic Shaping per Policy-Map

Traffic shaping can be applied *per class* or *per policy map* (multiple classes). The *per policy-map* shaper effects all traffic transiting the policy. The aggregate bandwidth of all classes (one configured with *bandwidth* and one with the **priority** command) within the policy is smaller or equal to the shaper's average committed rate. Individual traffic flows share the bandwidth and are prioritized within the shaper rate.

The per policy shaper may be useful in the following situations:

- *When a high- speed interface (Fast/GigabitEthernet) interfaces with a low-speed device such as a modem* where the downstream bandwidth is much smaller than the native Ethernet speed. The QoS policy map is applied to the output Ethernet interface and traffic must be prioritized but in accordance with the modem not Ethernet rate. To communicate this, the global shaper should be applied to the policy map with the average rate equal to or smaller than the modem speed.
- *On a virtual interface such as VPN which has no bandwidth associated with it.* Applying the per policy shaper to a virtual interface communicates the expected output bandwidth for that interface to QoS and enforces bandwidth sharing and prioritization.
- *Over ATM VC interfaces configured with UBR on the same ATM port* which may influence each other's traffic. Applying the policy-map with shaper restricts the VC to a portion of the available port bandwidth and enforces bandwidth sharing and prioritization.

Caution: When applied on a per policy basis, the shaper restricts output line bandwidth to the average shaper rate. If the actual output line bandwidth is bigger than the shaper rate, the shaper will *stop traffic from using the entire output bandwidth*.

The normal burst determines the biggest burst on the output interface and, as such, normal burst should always be bigger than the biggest PDU size otherwise it may block traffic. The XSR will produce a message concerning this situation but will not automatically increase the global shaper burst.

The per policy shaper coexists with other QoS features such as shaping per traffic class, RED, queue-limits, and others and does not affect their functionality. It is applied to the *output port only* and has no effect if the policy map is configured on the input port.

In the following example, class *cbts* is shaped to 128 kbps. The overall *cbts* bandwidth is 128 Kbps and if *cbts* is applied to the Ethernet interface the maximum egress rate would be 128 Kbps. Since traffic classes share bandwidth within 128 Kbps, the priority class should not be configured more than 75 percent of the shaper rate because if it sends with its maximum configured rate it may stall all other traffic (including internally prioritized traffic such as RIP, OSPF and others).

```
XSR(config)#policy-map cbts
XSR(config-pmap<cbts>)#shape 128000
XSR(config-pmap<cbts>)#class d32
XSR(config-pmap-c<d32>)#priority high 30
```

```
XSR(config-pmap-c<d32>)#exit
XSR(config-pmap<cbts>)#class foo
XSR(config-pmap-c<foo>)#shape 38400 15440
XSR(config-pmap-c<foo>)#bandwidth per 30
XSR(config-pmap-c<foo>)#exit
XSR(config-pmap<cbts>)#class class-default
XSR(config-pmap-c<class-default>)#set ip dscp 33
```

Differences Between Traffic Policing and Traffic Shaping

Traffic shaping and traffic policing may appear identical at first glance, but are marked by the following differences:

- Traffic policing marks or drops packets, it does not buffer them and has no associated queue management algorithm.
- The **police** command configures independent input and output rate-limit rules on the same interface while traffic shaping applies to *output* only.
- Traffic policing can be used to implement CAR (Committed Access Rate). You can specify both *conform-action* and *exceed-action*. If the exceed-action is *drop*, then the rate limit is essentially a CAR rate. Traffic-shaping has no such parameters as all *in-profile* traffic will be forwarded or queued and *out-of-profile* traffic queued and shaped.
- Traffic shaping and policing differ in how they refill the token bucket. Shaping add tokens in the bucket at regular intervals of 10 milliseconds and calculates token added using this formula: *tokens equal 10 millisecond rate*.
  The Policer adds tokens to the bucket on every packet, calculating the interval between the current and previous packet to determine the number of tokens it must add using this formula: *tokens equal (interval between packets) multiplied by rate divided by 8bits*

Traffic Shaping and Queue Limit

Traffic shaping delays packets in the queue if there are too few tokens in the bucket. How many packets are delayed (queued) depends on the shaper values, refill interval of the token bucket (10 milliseconds) and incoming traffic. If too many packets are delayed, the queue may overflow and incoming packets get dropped, so the queue size must be correct to avoid unwanted dropped packets.

The queue may also overflow because incoming traffic is significantly beyond expected parameters. The XSR has no control over incoming traffic and if it misbehaves, no shaping configuration will prevent packet drops.

Another cause for the queue overflowing is its size may not be big enough to sustain the configured average rate. Since every 10 milliseconds QoS fills the bucket, the queue should be configured with enough capacity to hold a 10msec burst. This is the minimum queue size required to sustain the average rate. Use the following formula to calculate the queue size:

Shape burst equals (rate multiplied by (10msec/1000) divided by (minimum packet size multiplied 8 bits)

If incoming traffic is expected to be bursty and the expected burst is bigger than the queue size, packets will be dropped. You can hike the queue size to accommodate incoming bursts as follows:

Expected burst equals burst (in bytes) divided by (minimum packet size)

The XSR automatically calculates *shaper* burst and you configure *expected* burst using the **queue-limit** command. When both queue-limit and shaper are configured on a queue, QoS uses the

queue-limit value for the queue size. Be aware that by setting the queue size smaller than the shaper burst, shape will not be able to achieve the configured average rate. When the queue-limit command is not invoked, queue size is determined only by the shaper burst.

Congestion Control & Avoidance

Describing Queue Size Control (Drop Tail)

By using delay control and congestion avoidance, you control queued up packets. If an outgoing queue is empty when a packet is ready to be sent, the packet can be forwarded immediately to the line with minimal delay. But, if there are 20 queued packets in the outgoing queue when the packet arrives, the new packet must wait until the 20 queued packets are sent before it can go.

Depending on the average packet size of the queued packets and the speed of the link, this last packet could be delayed considerably. When the queue limit is reached no new arriving packets are accepted in the queue and are dropped. The limit of the queue is set by the **queue-limit** command as shown in the following example:

```
XSR(config)#policy-map droptail
XSR(config-pmap<droptail>)#class the_heat
XSR(config-pmap-c<the_heat>)#queue-limit 50
```

Describing Random Early Detection

Random Early Detection (RED) is a congestion avoidance mechanism for adaptive applications (e.g., TCP/IP) that adjusts bandwidth usage of the XSR based on network conditions. TCP/IP uses a slow-start feature that initially sends a few packets to test network conditions.

If the acknowledgement returns indicating no packet loss, TCP considers the network capable of handling more traffic and increases its output rate. The protocol continues to do so until it detects any packets dropped and not delivered, at which point it considers the network congested and begins cutting back the output rate.

Because of TCP's slow-start/fast-drop-off behavior when dealing with congestion, TCP/IP's performance is choppy when the node or network is heavily loaded and the network does not apply congestion avoidance. This occurs because when the node is congested and the outgoing queue fills up, subsequent packets (very likely from multiple TCP sessions) are dropped, and these in turn cause corresponding TCP sessions to dramatically cut output.

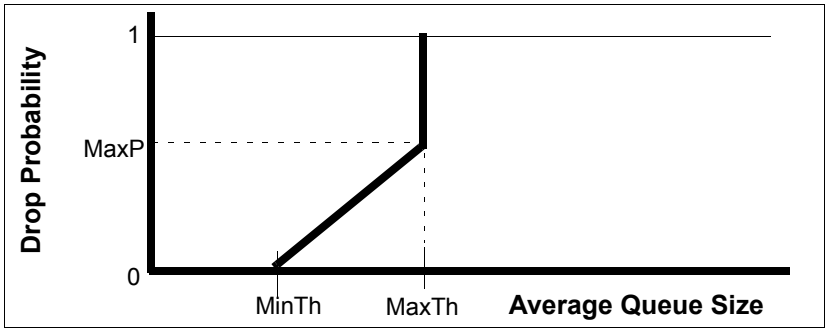
After a short delay, all sessions try to ramp up using slow-start in a process called Global Synchronization. The queue grows, congestion and packet drops recur, and undesirable global synchronization repeats. The end result is a distinctive "peak and trough" traffic pattern where the outgoing queue is full just before packets are dropped, delay throughout the network is high and varies by large margins.

RED tries avoiding congestion by proactively dropping packets randomly at an early sign of congestion (when the queue rises above the threshold). Because packets are dropped randomly, all TCP/IP sessions will be affected eventually and the treatment made fair to all sessions.

By dropping packets early - before it reaches its queue limit - RED starts to "throttle" the traffic source before the queue grows too large. It helps limit delay, which is proportional to the number of packets in the queue, and avoid queue overflow and global TCP synchronization.

The **random-detect** command includes three parameters to configure RED for a queue: minimum threshold (*MinThres*), maximum threshold (*MaxThres*) and maximum drop probability (*MaxProb*). The drop probability of a packet is based on the average queue size and the three parameters mentioned earlier. The calculation of the drop probability is pictured below.

Figure 12-1 RED Drop Probability Calculation



In the following example, class *bus* has a minimum threshold of 460. RED will start to randomly (with a probability between 0 and 1/10) discard packets when its queue grows over 460 packets. It will start to discard each packet when the queue holds more than 550 packets.

Note: Drop Tail and RED cannot be used on the same queue at the same time. - *queue-limit* and *random-detect* are mutually exclusive. If *random-detect* is set on a queue, *queue-limit* cannot be set on the same queue until RED is removed.

Describing Weighted Random Early Detection

Weighted Random Early Detection (WRED) is variant of RED that combines RED's capability of selectively dropping packets with DSCP or IP precedence marking. WED's three parameters (*MinTh*, *MaxTh* and *MaxP*), may have different values for different DSCP or IP precedence and, as a consequence, dropping probability will differ between DSCP/IP precedence markings.

You can configure MinT, MaxT and MaxP parameters for each DSCP/IP precedence value. If no parameters are defined, WRED uses default values. For a particular queue, WRED drops packets based only on one type of marking: DSCP or IP Precedence, meaning WRED can be configured as DSCP or IP precedence-based but not both at same time. WRED can be applied to priority or fair bandwidth class.

In the following configuration, DSCP value *af11* has a minimum threshold of *300*. For all other DSCP values, WRED parameters are set to *460*, *550*, and *10*. When the queue for class *bus* grows larger than 300 packets, WRED starts randomly (with a probability between 0 and 1/20) discarding packets with a DSCP marking of *af11*.

For all other DSCP values, WRED starts randomly discarding packets with a probability between 0 and 1/10 when its queue grows larger than 460 packets. It discards all packets with DSCP *af11* when the queue is larger than 350, and discards all other packets when the queue is larger than 550 packets. Clearly, packets with DSCP *af11* will be discarded more often than packets with other DSCP values.

```
XSR(config)#policy-map ppwe
XSR(config-pmap<ppwe>)#class voip
XSR(config-pmap-c<voip>)#priority high 64 1000
XSR(config-pmap<ppwe>)#class bus
XSR(config-pmap-c<bus>)#bandwidth percent 30
XSR(config-pmap-c<bus>)#random-detect dscp-based
XSR(config-pmap-c<bus>)#random-detect dscp af11 300 350 20
XSR(config-pmap-c<bus>)#random-detect dscp default 460 550 10
```

WRED is important because it complies with *Diff Serve*, whose specification has three drop levels for AF classes. When congested, packets with a higher drop DSCP marking should be discarded statistically more often than packets with a lower drop marking. This can be achieved by using

WRED. Traffic marked with a lower drop probability is assigned a higher *MaxP*, and bigger thresholds for *MinTh* and *MaxTh* than traffic marked with DSCP values having a higher drop level. Because higher drop DSCPs have a lower *MinTh*, as the queue grows, the XSR starts discarding them earlier than low drop DSCPs. Also, the XSR drops them more often because they have a higher drop probability (*MaxProb*). The end effect is that packets marked with high-drop DSCP values are discarded more frequently.

Note: Drop Tail and WRED cannot be used on the same queue simultaneously - *queue-limit* and *random-detect* are mutually exclusive. If *random-detect* is set on a queue, *queue-limit* cannot be set as well until WRED is removed.

The XSR treats RED as a subclass of WRED because it becomes equivalent to RED when all DSCP or precedence values have the same minth, maxth, and maxprob values. While you can implement RED by configuring WRED, RED may still be configured by itself using the **`random-detect`** command as illustrated in the following example. These two configurations are equivalent - both configure RED with MinTh=10, MaxTh=20 and MaxProb=1 although the first uses *random-detect* while the second uses WRED.

```
XSR(config)#policy-map ppwe
XSR(config-pmap<ppwe>)#class bus
XSR(config-pmap-c<bus>)#random-detect 10 20 10
XSR(config)#policy-map ppwe
XSR(config-pmap<ppwe>)#class bus
XSR(config-pmap-c<bus>)#random-detect dscp-based
XSR(config-pmap-c<bus>)#random-detect dscp default 10 20 10
```

Configuration per Interface

QoS can be configured on both LAN and WAN interfaces, sub-interfaces (Frame Relay DLCI, ATM, Ethernet VLAN) , and virtual interfaces (Dialer, VPN). Table 12-2 illustrates the options:

Table 12-2 Configuration Options by LAN/WAN Interface

Function	Ethernet	Serial	PPP	MLPPP	FR DLCI	Dialer	VPN
CBWFQ	Y	Y	Y	Y	Y	Y	Y
Priority Queue	Y	Y	Y	Y	Y	Y	Y
Traffic Policing	Y	Y	Y	Y	Y	Y	Y
Random Early Detect	Y	Y	Y	Y	Y	Y	Y
WRED	Y	Y	Y	Y	Y	Y	Y
Traffic Shaping per class	Y	Y	Y	Y	Y	Y	Y
Traffic Shaping per policy	Y	Y	Y	Y	Y	Y	Y
Service Map input	Y	Y	Y	Y	Y	Y	Y
Service Map output	Y	Y	Y	Y	Y	Y	Y

The Dialer interface is a virtual interface in the sense that it does not have a corresponding transmit port (serial or Ethernet). Only after it dials does the dialer interface bind to one of the resources from the dialing pool (Serial port) and establish a data path. Service policy applied to

the dialer interface is pushed to binded serial and, when disconnected, is removed from the serial port. Refer to "Configuring PPP" on page 8-1.

Suggestions for Using QoS on the XSR

The XSR supports QoS on all interfaces but you should enable QoS only on the data path that actually requires it (generally on lower speed Frame Relay and PPP interfaces) because QoS is fairly processor intensive and may adversely impact router performance.

In a typical XSR environment, QoS may be enabled on the WAN link. The following lists two configuration scenarios:

- A standard office IP application, with no multi-media programs:
  - Enable PQ or CBWFQ
- A complex office application, with multi-media applications:
  - Use *high* Priority Queue for VoIP traffic with a cap on bandwidth it may consume
  - Use *medium* Priority Queue for control packets with a cap on bandwidth
  - Use *CBWFQ* queue for interactive traffic - Telnet, Web access
  - Use *CBWFQ* with *RED* for remaining traffic
  - Use Frame Relay fragmentation if the WAN link is Frame Relay with multiple DLCIs

Also, if the WAN link is running Frame Relay, you may enable generic traffic shaping to specify the Committed Information Rate (CIR), FECN and BECN options to control link throughput. Similarly, you can set policing to limit input and output rates of a PPP link (in situations where the delivery mechanism has higher throughput capability than the subscribed rate (e.g., the service could be delivery on 10 Mbps Ethernet, but you have subscribed only to 128 kbps). This ensures that the node conforms to the bandwidth level of any Service Level Agreement.

QoS and Link Fragmentation and Interleaving (LFI)

Latency sensitive traffic such as Voice over IP (VOIP) is susceptible to increased latency when the network processes large packets such as FTP transfers traversing a WAN. Packet delay is especially significant when the FTP packets are queued over slower links. A large 1500 byte packets takes 215 milliseconds to traverse a 56-kbps line, which exceeds the delay target of 150 milliseconds for real-time packets.

That being the case, Link Fragmentation and Interleaving (LFI), in association with QoS, reduces delay on slower-speed links by breaking up large datagrams and interleaving latency-sensitive packets with smaller packets resulting from the fragmented datagram. QoS classifies latency-sensitive packets into priority queues, schedules packets from the priority queues for transmission prior to packets from non-priority queues and delivers them to the LFI mechanism for fragmentation and interleaving with fragments from other traffic streams. The XSR implements LFI using Multi-link PPP (MLPPP) with multi-class or Frame Relay with FRF12.

Configuring QoS with MLPPP Multi-Class

Configuring QoS with MLPPP multi-class requires creating a MLPPP interface with multi-class. You set the fragment size using the fragment delay where a minimum value is 10 milliseconds. The XSR uses fragment delay and the link speed to calculate the size of the fragment, and splits all packets transiting this interface with this size. If a priority packet is fragmented, its fragments are interleaved with fragments from the other packets.

QoS with MLPPP multi-class regulates the output queue in such a way that, ideally, there is at most one non-priority packet in front of the priority packet so the greatest latency that latency-sensitive packets experience is never bigger than the fragment delay. Practically speaking, latency for priority packets may be in the range of one to three fragment delays, depending on the traffic, link speed and type of interface used.

QoS with MLPPP multi-class is configured by adding a class map for priority traffic and marking it as a high priority class in the QoS policy map. That will allow priority packets to be scheduled before other packets. Then to activate QoS, the policy is applied to the MLPPP interface.

Refer to "QoS with MLPPP Multi-Class Policy" on page 12-26 for a configuration example.

Configuring QoS with FRF.12

Configuring QoS with FRF.12 is similar to configuring QoS with MLPPP multi-class except that the FRF.12 fragment size is configured in *bytes*. The smaller the fragment size the smaller latency for priority packets but the bigger the overhead for packet processing and link utilization.

Besides raising concerns about efficiency and utilization, setting a low fragment size may negate the advantage of FRF.12 interleaving which interleaves packets within fragments. That is, multiple fragmented packets are *not* interleaved. If the fragment size is smaller than the size of priority packets, the priority packets will be chopped and FRF.12 will not insert its fragments into the output fragment stream. In this case, fragments from priority packet must wait until all fragments from the previous packets are transmitted thus causing heavy latency. In order to maximize the benefit from FRF.12 interleaving, priority packets should be smaller than the fragment size. This restriction does not exist for MLPPP multi-class.

For a sample configuration, refer to "QoS with FRF.12 Policy" on page 12-27. Note that the same QoS configuration is used for MLPPP and Frame Relay.

QoS with VLAN

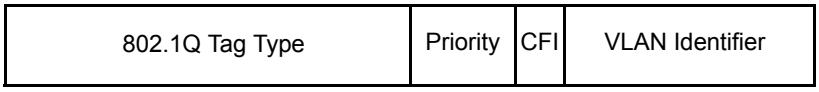
The IEEE 802.1P signaling technique prioritizes network traffic at the data-link/MAC sublayer (Layer 2). The 802.1P header includes a three-bit field for prioritization, which allows packets to be grouped into various traffic classes. 802.1P is a spin-off of the 802.1Q (VLANs tagging) standard and they work in tandem. The 802.1Q standard specifies a tag that appends to a MAC frame. The two-part VLAN tag carries VLAN information including the 12-bit VLAN ID and 3-bit Prioritization.

Additionally, 802.1P establishes eight levels of priority similar to IP Precedence levels. The XSR permits mapping 802.1P prioritization to IP Precedence or DSCP before forwarding to the output line and in reverse.

Traffic Classification

The XSR provides traffic classification based on the *priority bits* in the VLAN header, as illustrated graphically below. For a VLAN connection, the XSR can use the 3-bit traffic class data in the 802.1q header to convey the QoS classification of the encapsulated data.

Figure 12-2 Priority Information within VLAN 802.1q Header



Describing VLAN QoS Packet Flow

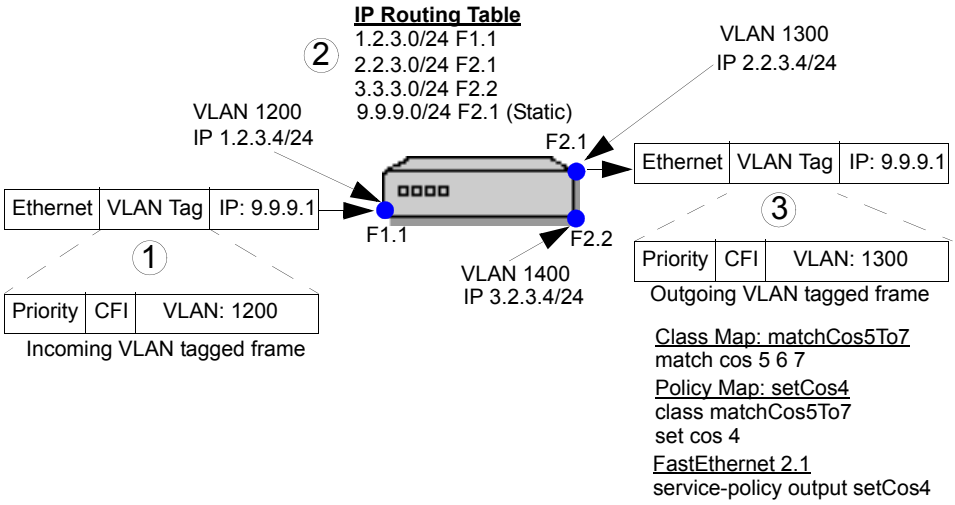
The following scenarios illustrate how prioritized VLAN and non-VLAN packets behave across XSR interfaces with VLAN and QoS configured and include minimal CLI commands.

VLAN Packet with Priority Routed out a Fast/GigabitEthernet Interface

The following scenario is illustrated in Figure 12-3.

1. After the XSR accepts a VLAN-tagged Ethernet frame, the tag is stripped and the VLAN ID within the tag is used in the process of mapping the frame to a sub-interface of the Fast/GigabitEthernet interface. The priority bits are stored internally with the frame.
2. The IP packet in the Ethernet frame is routed according to the XSR's forwarding table which learns the next hop and outgoing interface.
3. If the outgoing port is associated with a VLAN by a <VLAN ID>, the XSR will create a VLAN tag with the <VLAN ID> and insert it in the outgoing Ethernet frame. Also, if priority bits are stored with the frame, they will be marked in the VLAN tag. Lastly, if QoS is configured on the XSR's output interface, it will be applied accordingly. In this case, the policy map *setCos4* is applied to the output sub-interface FastEthernet 2.1. Since the input priority was *7*, it will match the class *matchCos5To7*. The output VLAN frame will be marked with a priority of *4*.

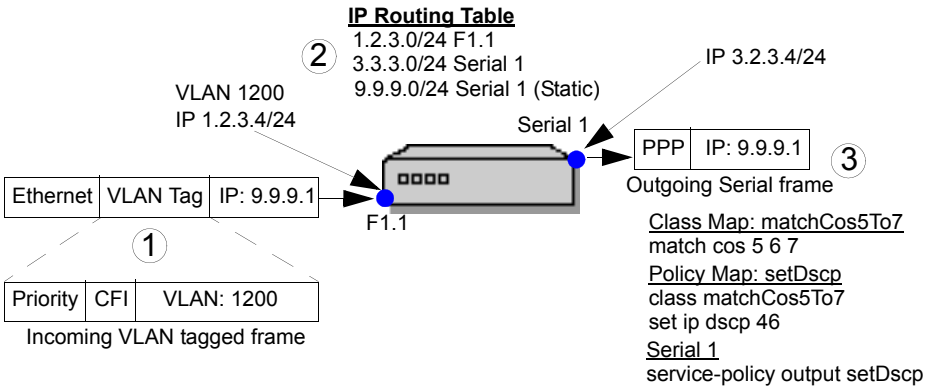
Figure 12-3 VLAN/QoS Ethernet Scenario



VLAN Packet with Priority Routed out a Serial Interface

In this scenarios, pictured in Figure 12-4, the policy map *setDscp* is applied to the output interface Serial 1. Since the input priority was *7* it will match the class *matchCos5To7*. The IP packet will be marked with a DSCP of *46*.

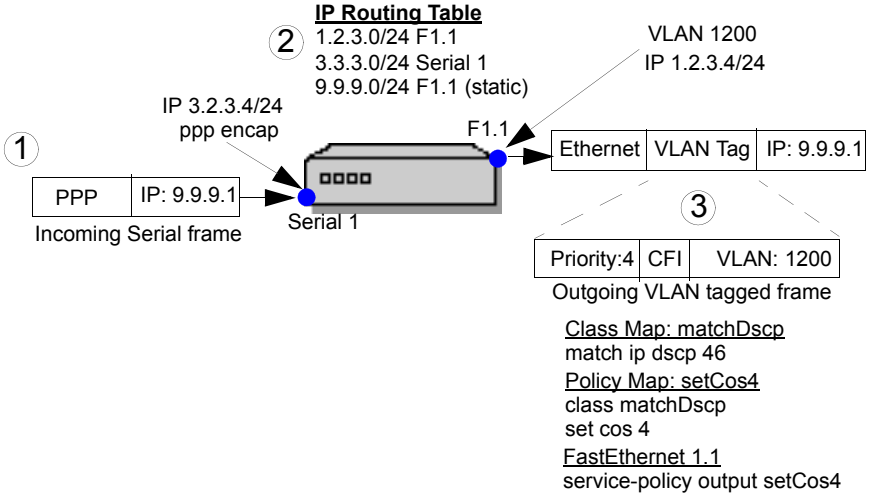
Figure 12-4 LAN/QoS Serial Scenario



Non-VLAN IP Packet Routed Out a Fast/GigabitEthernet Interface

In this scenario, shown in Figure 12-5, the policy map *setCos4* is applied to the output interface FastEthernet 1.1. Since the input IP DSCP was 46 it will match the class *matchDscp*. The output VLAN frame will be marked with a priority of *4*.

Figure 12-5 Non-VLAN Packet Scenario



QoS with VLAN Configuration Process

Follow the steps below to configure the XSR for QoS with VLAN routing.

1. Configure a sub-interface.
   `interface <Interface name> <slot/card/number>`
2. Stipulate a VLAN ID on the sub-interface.
   `vlan <number>`
3. Specify an IP address on a sub-interface.
   `ip address <IP address> <mask>`
4. Add a traffic class.
   `class-map <match-all | match-any> <class-map name>`
5. Match the IEEE 802.1 priority in the input VLAN header.
   `match cos <0 - 7>`

Priority levels range from 0 (lowest) to 7.

6. Create a traffic policy.
   `policy-map <policy-map-name>`
7. *Optional*. Mark the IEEE 802.1 priority in the output VLAN header.
   `set cos <0 - 7>`
8. Attach the service policy to the input or output interface.
   `interface <Interface name> <slot/card/number> service-policy <input | output> <policy-map-name>`

You can set the service policy on an incoming or outgoing interface.

Refer to "QoS with VLAN Policy" on page 12-28 for a configuration example.

QoS on Input

QoS on input and QoS on output share a common configuration and set of features. QoS on input is configured with a policy map in the same way as Qos on output - with the **`service-policy input policy-map-name`** command. One policy map may be applied at the same time on one interface as input and on the other as output. QoS features that are configured on the policy map but are not applicable to input direction are automatically removed by the XSR.

QoS on input shares the following features with the Qos on output:

- *Classification* by class-maps: Both QoS on input and output provide classification
- *Marking per traffic flow*: QoS on input marks DSCP and IP precedence fields
- Policing per traffic class with actions for exceed and violate traffic

An exception to the shared qualities: QoS on input does not buffer packets - it applies QoS actions on a packet-per-packet basis with no buffering. Other output QoS features not performed by QoS on input include:

- Shaping
- Bandwidth sharing with the **`bandwidth`** command
- Prioritization with the **`priority`** command
- Marking of the CoS bit in the VLAN header
- RED or WRED

For QoS on Input configuration examples, refer to "Input and Output QoS Policy" on page 12-28 and subsequent examples.

QoS on VPN

QoS on VPN provides classification, policing, marking, shaping, and prioritization for managing traffic that transits VPN tunnels. The XSR's implementation of QoS on VPN uses a class-based interface for configuring QoS similar to QoS configuration on other non-VPN interfaces.

In a typical VPN environment, packets are encrypted and/or encapsulated in VPN tunnels. The original packet header (*inner* header) and its contents are modified and encapsulated in a new packet with a new header (*outer* header). At the output physical interface only the outer header is visible. This situation presents a challenge for QoS on the output interface to identify and classify packets based on the inner header and their original content. But it is addressed by the XSR's support of copying ToS bits from the inner to the outer header with the **`copy-tos`** command.

The XSR offers you two choices in applying QoS service policy:

- *before* encryption on the VPN tunnel (*virtual* VPN) interface or,
- *after* encryption on the underlying *physical* interface.

Copying of the ToS byte brings into play security concerns you must address. As described in RFCs 2475 and 2983, copying of ToS bits may not always be desirable. This is because packets with different ToS bits may reveal information about characteristics of the tunneled traffic and also may be susceptible to Denial of Service attacks when a hacker changes ToS bits and resends the packets. So, the decision to configure this feature is your choice. The XSR supports the following QoS on VPN scenarios:

- *QoS on a physical interface* - If you want to classify packets based solely on the *outer* header, apply your service policy to the physical interface (e.g., **`S1/1.1`**).
- *QoS on the virtual tunnel interface* - If you wants to classify packets based on the *inner* header - before encryption - apply your service policy to the virtual tunnel interface (e.g., **`VPN1`**).

QoS over VPN Features

The XSR supports the following QoS over VPN features:

- QoS on a physical interface
- QoS on a VPN virtual interface, configured with the **`service-policy`** command
- Values set on a VPN interface apply to all supported protocols: GRE, IPSec, PPTP, L2TP, e.g.
- Packet classification, marking, policing and shaping
- ToS bit copy option during encapsulation/decapsulation with the **`copy-tos`** command
- On multi-point virtual interfaces, the QoS policy map is configured on the *virtual* interface. When a connection is established with a particular user, the policy map is applied to that neighbor and all neighbors are configured with the same policy map.
- Control traffic traversing the virtual interface (RIP, OSPF, etc.) is internally marked and prioritized on the *output* physical interface.
- Classifying, marking and policing is *not available* for IPSec site-to-site tunnels not employing the VPN interface but ToS bit is supported. Copying ToS bit is configurable on a per-per peer with the **`crypto isamp peer`** command. In the case when an IPSec tunnel is copying ToS bits configured on a VPN interface and for a peer, peer configuration takes precedence.

Configuring QoS on a Physical Interface

QoS applied to physical interfaces with a crypto map is not significantly different than QoS applied to other interfaces. You should keep in mind that QoS set to an interface with a crypto map classifies flows using the outer header of previously encrypted packets. As mentioned earlier in this section, the inner header is encrypted and QoS can not classify packets based on the user (inner) header. The only exception to this rule are the ToS bits. If you configure *copy-tos*, then the inner header ToS byte is copied to the outer header and made accessible to QoS.

Configuring QoS on a Virtual Tunnel Interface

QoS on an virtual VPN tunnel requires classification to be applied *before* encryption (hardware or software). The VPN interface represents a point-to-point tunnel and as each tunnel represents a tunnel encapsulation mechanism, this process may also involve copying ToS bits from the inner to

outer header. In this scenario, all QoS-related parameters are attached to the VPN interface. Note that the VPN interface is a virtual interface without any bandwidth attached to it so certain QoS operations may not be applied here, namely, scheduling packets. But, other QoS parameters which can be applied include:

- Classification
- Marking packets
- Policing packets
- Buffer management
- Shaping on the VPN interface

QoS provides prioritization for low-latency packets. QoS on virtual tunnel has no fixed bandwidth so there is no enforcement of bandwidth sharing. In conjunction with the per policy shaper, QoS on VPN may provide bandwidth sharing within the specified bandwidth for the global shaper.

QoS marks the ToS byte of the inner header before it is copied to the outer header. To make marking available to the outer header, you must configure the VPN interface to copy the ToS byte with the **`copy-tos`** command. Note that ToS byte copying occurs independently of the QoS process. The ToS byte may be copied without even configuring QoS on the VPN interface.

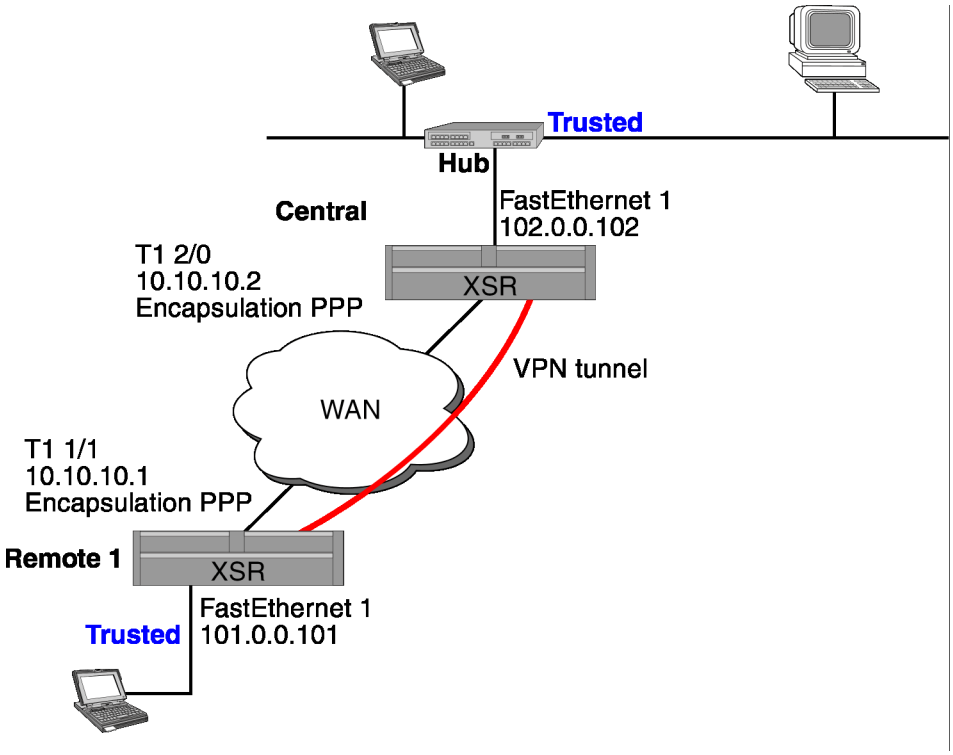
QoS on a Virtual Interface Example

In the following example, as shown topologically in Figure 12-6, trusted networks 101.0.0.0 and 102.0.0.0 are connected by a VPN site-to-site tunnel, established between XSR Remote 1 and XSR Central over Serial interface 1/0:0. Tunnel traffic consists of latency-sensitive RTP traffic and best-effort FTP traffic.

Since the serial interface is a point of congestion, you should prioritize the RTP traffic and allocate 20% of the link bandwidth for the FTP traffic during congested periods. Other traffic that may traverse Serial 1 is allocated the remaining bandwidth (totaling 80%). You will reserve 100 Kbps of the link for RTP assuming that that will be maximum requirement for RTP. In this example, QoS is defined only in the direction of Remote1 *to* Central. For a complete solution, QoS should be applied on the XSR Central Serial interface as well.

It is clear that by applying QoS on Serial 1/0:0 (after encryption), you will not be able to distinguish RTP packets from the FTP. One way to solve this problem is to mark packets with distinct DSCP values before they are encrypted, on the virtual interface, and copy the ToS bits to the outer header. Traffic is classified with the policy map *Vpn* applied on the VPN interface. policy map *Vpn* marks RTP packets with *DSCP 46* and FTP with *DSCP 18*. On the output Serial port, policy map *Ser* distinguishes RTP and FTP packets from the tunnel using the DSCP byte on the outer header which provides proper traffic management.

Figure 12-6 QoS on a Virtual Interface Example



The following commands configure *Ser* and *Vpn* policy maps on the XSR Remote 1 as shown in Figure 12-7. XSR Central configuration is not described.

Configure the QoS Class Maps RTP and FTP matched to ACLs 110 and 15:

```
XSR(config)#class-map RTP
XSR(config-cmap<RTP)#match access-group 110
XSR(config-cmap<RTP)#exit
XSR(config)#class-map FTP
XSR(config-cmap<FTP)#match access-group 115
XSR(config-cmap<FTP)#exit

XSR(config)#class-map RTP1
XSR(config-cmap<RTP1)#match ip dscp 46
XSR(config-cmap<RTP1)#exit
XSR(config)#class-map FTP1
XSR(config-cmap<FTP1)#match ip dscp 18
```

Configure the input policy map *Vpn* classes *RTP* and *FTP*:

```
XSR(config)#policy-map Vpn
XSR(config-pmap-VPN>)#class RTP
XSR(config-pmap-c<RTP>)#set ip dscp 46
XSR(config-pmap-c<RTP>)#police 100000
XSR(config-pmap-c<RTP>)#class FTP
XSR(config-pmap-c<RTP>)#set ip dscp 18
XSR(config-pmap-c<RTP>)#class class-default
XSR(config-pmap-c<RTP>)#set ip dscp 8
```

Configure the output policy map *Ser* classes *RTP1* and *FTP1*:

```
XSR(config)#policy-map Ser
XSR(config-pmap-Ser>)#class RTP1
XSR(config-pmap-c<RTP1>)#priority high 100
XSR(config-pmap-c<RTP1>)#exit
XSR(config-pmap-Ser>)#class FTP1
XSR(config-pmap-c<FTP1>)#bandwidth percent 20
XSR(config-pmap-c<FTP1>)#exit
XSR(config-pmap-Ser>)#class class-default
XSR(config-pmap-c<class-default>)#set ip dscp 8
```

Configure ACLs:

```
XSR(config)#access-list 100 permit ip 101.0.0.0 0.0.0.255 102.0.0.0 0.0.0.255
XSR(config)#access-list 110 permit udp any 102.0.0.0 0.0.0.255 eq 3020
XSR(config)#access-list 115 permit tcp any 102.0.0.0 0.0.0.255 range 20 21
```

Configure the IKE policy *foo* for pre-share keys:

```
XSR(config)#crypto isakmp proposal foo
XSR(config-isakmp)#authentication pre-share
XSR(config-isakmp)#hash md5
XSR(config-isakmp)#exit

XSR(config)#crypto isakmp peer 0.0.0.0 0.0.0.0
XSR(config-isakmp-peer)#proposal foo
```

Configure the IPSec SA:

```
XSR(config)#crypto ipsec transform-set test esp-3des esp-md5-hmac
XSR(cfg-crypto-tran)#no set security-association lifetime kilobytes
XSR(cfg-crypto-tran)#no set security-association lifetime seconds
XSR(cfg-crypto-tran)#exit

XSR(config)#crypto map test 10
XSR(config-crypto-m)#set transform-set test
XSR(config-crypto-m)#match address 100
XSR(config-crypto-m)#set peer 10.10.10.2
```

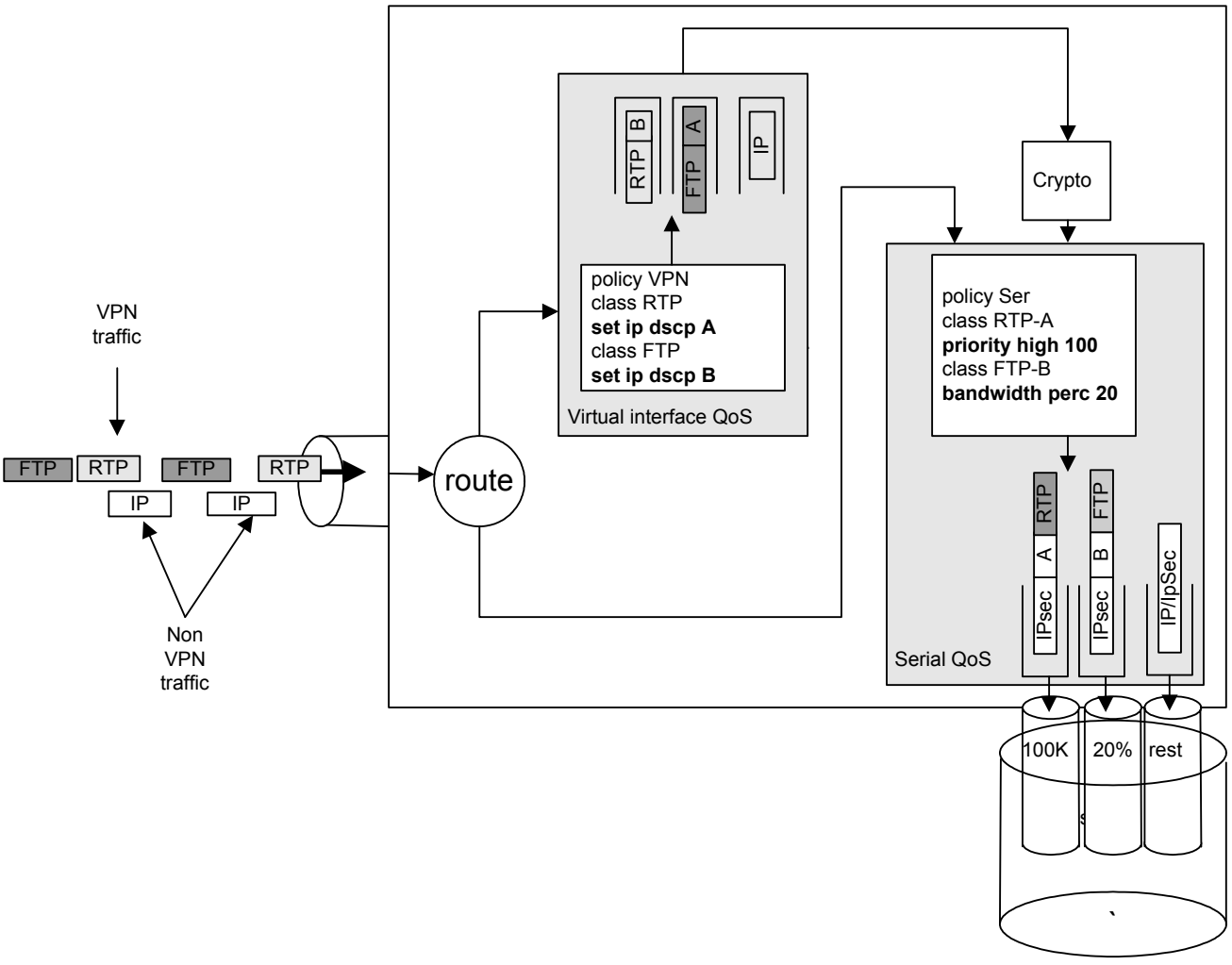
Configure GigabitEthernet interface 2 and Serial sub-interface 1/0:0

```
XSR(config)#interface GigabitEthernet 2
XSR(config-if<G1>)#ip address 101.0.0.101 255.255.255.0
XSR(config-if<G1>)#no shutdown
XSR(config-if<G1>)#exit

XSR(config)#interface serial 1/0
XSR(config<S1/1>)#exit
XSR(config)#interface serial 1/0:0
XSR(config-if<S1/0:0>)#crypto map test
XSR(config-if<S1/0:0>)#encapsulation ppp
XSR(config-if<S1/0:0>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<S1/0:0>)#service-policy output Ser
XSR(config-if<S1/0:0>)#no shutdown
```

Configure output VPN interface 1 for ToS byte copying, GRE, and other values:

```
XSR(config)#interface vpn 1
XSR(config-int-vpn)#ip address 20.20.20.1/24
XSR(config-int-vpn)#copy-tos
XSR(config-int-vpn)#service-policy output vpn
XSR(config-tms-tunnel)#tunnel t1
XSR(config-tms-tunnel)#set protocol gre
XSR(config-tms-tunnel)#set peer 10.10.10.2
XSR(config-tms-tunnel)#set active
XSR(config-tms-tunnel)#no shutdown
```

Figure 12-7 Bandwidth Allocation of VPN/Non-VPN Traffic on Virtual Interface



QoS and VPN Interaction

The mechanism underlying the VPN interface requires that packets be routed twice in the packet processor. In their first pass, packet s are routed from the input interface to the VPN interface and in the second pass, they are routed from the VPN interface to the output physical port. The output physical port is determined purely by routing information and can change over time as the reachability of the tunnel peer changes. As a result, the VPN interface and consequently QoS has no prior knowledge about the output physical port.

This situation can cause unexpected results when QoS is applied to VPN interfaces. If the rate of traffic traversing the VPN interface is higher than the physical interface bandwidth, packets are dropped after they are sent from the VPN interface. Due to this, QoS statistics may show higher available bandwidth on the VPN interface than the actual output rate on the physical line. For the same reason, QoS bandwidth sharing on the VPN interface is not enforced, although you may configure it.

When configuring QoS on the VPN interface you should keep the following in mind:

- If the physical interface that establishes the tunnel is congested, QoS on the VPN interface may show higher send rates than the actual line speed. To avoid this behavior you should apply the shaper per policy map on the VPN interface as described in the next section.
- QoS on VPN does not provide bandwidth sharing although you may configure it. To activate bandwidth sharing, apply shaper per policy map as described in the next section.
- The priority traffic (class) should be allocated lower reserved bandwidth than the physical interface or, if the shaper per policy is applied, reserved bandwidth should be lower than the shaper rate. If you ignore this rule all non-priority traffic may be stopped when the line becomes congested because priority queues are always serviced first.
- When QoS is applied on physical interfaces that implement crypto maps, reordering of the packets by QoS may trigger anti-reply IPSec protection at the receiving tunnel end. To avoid this problem, anti-reply should be disabled or QoS not used on the receive side.

Configuring the Shaper on the VPN Interface

If bandwidth sharing on the VPN interface is required you can communicate the expected or required bandwidth to QoS by applying shaper per policy map on the VPN interface. The shaper limits traffic that transits the VPN interface and collaborates with QoS to enforce bandwidth sharing.

In the following example, classes *c1* and *class default* share 1 Mbps bandwidth. Class *c1* has 100 Kbps reserved bandwidth while class default will get the remainder of the 1 Mbps. The output physical interface will receive at most 1 Mbps from this VPN interface.

```
XSR(config)#policy-map VPN
XSR(config-pmap<VPN>)#shape 1000000
XSR(config-pmap<VPN>)#class c1
XSR(config-pmap-c<class1>)#priority high 100
XSR(config-pmap-c<class1>)#exit
XSR(config-pmap<VPN>)#class class-default
XSR(config-pmap-c<class-defaul>)#set ip dscp 32
```

When you configure the shaper rate you must account for the expected overhead due to IPSec/GRE encapsulation. Packets traversing the VPN interface are purely user payload packets that later in the stack are encapsulated with tunnel headers. If the configured shaper rate does not account for encapsulation overhead, packets will be dropped during congestion on the physical interface, disturbing bandwidth sharing on the VPN interface. The table below outlines the approximate overhead values for different tunnel/IPsec configurations.

Table 12-3 Overhead on IPSec Tunnels

Tunnel Type	Mode	Tunnel IP Header	AH (HMAC)	ESP+3DES	Total Overhead
Tunnel AH	Tunnel	20 bytes	24 bytes	NA	44 bytes

Table 12-3 Overhead on IPSec Tunnels

Tunnel Type	Mode	Tunnel IP Header	AH (HMAC)	ESP+3DES	Total Overhead
Tunnel ESP	Tunnel	20 bytes	NA	24 bytes	44 bytes
Tunnel AH	Transport	NA	24 bytes	NA	24 bytes
Tunnel ESP	Transport	NA	NA	24 bytes	24 bytes

As an example, tunnels with ESP and 3DES encoding will add 44 bytes (or more) overhead. Padding for 3DES may add eight more bytes. Calculate the shaper rate with this formula:

ShaperRate = LineRate * (1 - OverHead/(OverHead +AvgPktSize))

The table below summarizes the shaper rate as a percentage from the line rate for different average packet sizes and tunnel modes. The larger the packet, the lesser tunnel overhead effect.

Table 12-4 Tunnel Shaper Rates

Packet Size	TunnelAH	Tunnel ESP	TransAH	TransESP
64	0.592593	0.592593	0.727273	0.727273
128	0.744186	0.744186	0.842105	0.842105
380	0.896226	0.896226	0.940594	0.940594
1084	0.958801	0.958801	0.977099	0.977099

QoS Policy Configuration Examples

Simple QoS on Physical Interface Policy

The following QoS example configures *Class1* with these characteristics on the Serial 1 /1 interface: a minimum of 200 Kbps of bandwidth are expected to be delivered to this class in the event of congestion, and the queue reserved for this class can enqueue 40 packets before tail drop is employed to handle additional packets.

Class2 is specified with these characteristics: a minimum of 300 Kbps of bandwidth are expected to be delivered to this class in the event of congestion. For congestion avoidance, RED packet drop is used, not tail drop. The *default* class is configured with a maximum of 20 packets per queue which are enqueued before tail drop is used to handle additional packets.

Begin by creating *Class1* and *Class2* and matching their respective parameters:

```
XSR(config)#class-map class1
XSR(config-cmap<class1)#match access-group 136
XSR(config-cmap<class1)#exit
XSR(config)#class-map class2
XSR(config-cmap<class2>)#match ip precedence 2
```

Create the policy map:

```
XSR(config)#policy-map policy1
XSR(config-pmap<policy1>)#class class1
XSR(config-pmap-c<class1>)#bandwidth 200
```

```
XSR(config-pmap-c<class1>)#queue-limit 40
XSR(config-pmap-c<class1>)#exit
XSR(config-pmap<policy1>)#class class2
XSR(config-pmap-c<class2>)#bandwidth 300
XSR(config-pmap-c<class2>)#random-detect 34 56 3
XSR(config-pmap-c<class2>)#exit
XSR(config-pmap<policy1>)#class class-default
XSR(config-pmap-c<class-default>)#queue-limit 20
XSR(config-pmap-c<class-default>)#exit
XSR(config-pmap<policy1>)#exit
```

Apply the configuration to the interface:

```
XSR(config)#interface serial 1/1
XSR(config-if<S1/1>)#service-policy output policy1
```

QoS for Frame Relay Policy

The following example sets Serial interface 1/1 for Frame Relay with one DLCI (100) which will support three types of traffic: *voice* that is assigned to a priority queue with a bandwidth of 20 kbps, *FTP* that is assigned to fair queue with 50 percent of the remaining bandwidth, and *Class1* that is assigned to class-default (and gets the other 50 percent). DLCI 100 sets CIR at 64 kbps (the sum of all PQs and classes should not exceed the CIR of the DLCI).

When the connection is congested, priority traffic will get its bandwidth share (smaller than the DLCI CIR) while all other classes share the remaining bandwidth proportional to what was requested. *Voice* is rate limited to 20 Kbps and the interval over which it is enforced is equivalent to burst/bandwidth size (2500 bytes/20 Kbps).

If no burst size is set, default burst size is used. Packets exceeding 20 Kbps are dropped. *Class1* and *FTP* are served after *voice* gets its share, but split the remaining bandwidth equally.

When there is no congestion each traffic class can use as much bandwidth as is available, except the voice which is priority class and is rate-limited to a maximum of 20 Kbps. BECN will adoptively reduce the CIR of the DLCI but does not influence the parameters of the policy-map *frame1*.

Begin by creating three ACLs to define traffic classes:

```
XSR(config)#access-list 101 permit udp 192.168.1.0 0.0.0.255 any eq 3000
XSR(config)#access-list 102 permit tcp 192.168.1.0 0.0.0.255 any eq 3000
XSR(config)#access-list 103 permit ip any any
```

Create classification maps using a combination of ACLs or IP DSCP or precedence bits to classify packets:

```
XSR(config)#class-map voice
XSR(config-cmap<voice>)#match access-group 101
XSR(config-cmap<voice>)#exit
XSR(config)#class-map ftp
XSR(config-cmap<ftp>)#match access-group 102
XSR(config-cmap<ftp>)#match ip dscp 18
XSR(config-cmap<ftp>)#match ip dscp 20
XSR(config-cmap<ftp>)#exit
XSR(config)#class-map match-any class-1
XSR(config-cmap<class-1>)#match access-group 103
```

Create a policy map consisting of one or more traffic classes and specify QoS characteristics for each traffic class:

```
XSR(config)#policy-map frame1
XSR(config-pmap<frame1>)#class voice
XSR(config-pmap-c<voice>)#priority high 20 2500
XSR(config-pmap-c<voice>)#queue-limit 32
XSR(config-pmap-c<voice>)#set ip dscp 46
XSR(config-pmap-c<voice>)#exit
XSR(config-pmap<frame1>)#class ftp
XSR(config-pmap-c<ftp>)#bandwidth percent 50
XSR(config-pmap-c<ftp>)#police 30000 3000 6000 conform-action set-dscp-transmit
10 exceed-action set-dscp-transmit 12 violate-action set-dscp-transmit 14
XSR(config-pmap-c<ftp>)#random-detect 20 35 250
XSR(config-pmap-c<ftp>)#exit
```

Configure map class parameters and apply the policy to the ports:

```
XSR(config)#map-class frame-relay cc
XSR(config-map-class<cc>)#frame-relay cir 64000
XSR(config-map-class<cc>)#frame-relay adaptive-shaping becn
XSR(config-map-class<cc>)#frame-relay bc 8000
XSR(config-map-class<cc>)#frame-relay be 16000
XSR(config-map-class<cc>)#service-policy out frame1
XSR(config-map-class<cc>)#exit

XSR(config)#interface serial 1/1
XSR(config-if<S1/1>)#encapsulation frame-relay
XSR(config<S1/1>)#frame-relay traffic-shaping
XSR(config<S1/1>)#no shutdown
XSR(config<S1/1>)#exit
XSR(config)#interface serial 1/1.1 point-to-point
XSR(config-subif<S1/1.1>)#frame-relay interface-dlci 100
XSR(config-fr-dlci<S1/1.1-100>)#frame-relay class cc
XSR(config-fr-dlci<S1/1.1-100>)#ip address 10.10.10.2 255.255.255.0
XSR(config-fr-dlci<S1/1.1-100>)#no shutdown
```

QoS with MLPPP Multi-Class Policy

In the following example, configure fragment delay to 10 milliseconds, classify RTP traffic as latency sensitive, match FTP traffic by FTP class, and allocate 30 percent of the output bandwidth. All other traffic is matched as default class. Also, fragment and interleave FTP packets and default-class packets with VoIP-RTP packets.

```
XSR(config)#class-map VoIP-RTP
XSR(config-cmap<VoIP-RTP>)#match access-group 101
XSR(config-cmap<VoIP-RTP>)#exit

XSR(config)#class-map FTP
XSR(config-cmap<FTP>)#match access-group 102
XSR(config-cmap<FTP>#exit

XSR(config)#policy-map QoS-Policy
```

```
XSR(config-pmap<QoS-Policy>)#class VoIP-RTP
XSR(config-pmap-c<class VoIP-RTP>)#priority high 100
XSR(config-pmap-c<class VoIP-RTP>)#class FTP
XSR(config-pmap-c<class VoIP-RTP>)#bandwidth per 30

XSR(config)#access-list 101 permit udp any any range 16384 32767
XSR(config)#access-list 102 permit udp any any range 20 21

XSR(config)#interface multilink 1
XSR(config-if<M1>)#ip address 10.1.61.1 255.255.255.0
XSR(config-if<M1>)#service-policy output QoS-Policy
XSR(config-if<M1>)#ppp multilink
XSR(config-if<M1>)#ppp multilink fragment-delay 10
XSR(config-if<M1>)#ppp multilink interleave
XSR(config-if<M1>)#multilink-group 1
XSR(config-if<M1>)#exit

XSR(config)#interface serial 1/0
XSR(config-if<S1>)#encapsulation ppp
XSR(config-if<S1>)#ppp multilink
XSR(config-if<S1>)#multilink-group 1
```

QoS with FRF.12 Policy

The following example configures QoS with FRF.12 fragmentation. Configuration is identical to the MLPPP multi-class example with class maps *VoIP* and *FTP* having similar priority and bandwidth values, and ACLs *101* and *102* permitting UDP traffic. But the configurations differ by the QoS policy here being set to a Serial sub-interface employing Frame Relay traffic shaping with various QoS burst and fragmentation parameters on Frame Relay map class *VoIP*.

```
XSR(config)#class-map VoIP-RTP
XSR(config-cmap<VoIP-RTP>)#match access-group 101
XSR(config-cmap<VoIP-RTP>)#exit
XSR(config)#class-map FTP
XSR(config-cmap<FTP>)#match access-group 102
XSR(config-cmap<FTP>)#exit
XSR(config)#policy-map QoS-Policy
XSR(config-pmap<QoS-Policy>)#class VoIP-RTP
XSR(config-pmap-c<class VoIP-RTP>)#priority high 100
XSR(config-pmap-c<class VoIP-RTP>)#class FTP
XSR(config-pmap-c<class VoIP-RTP>)#bandwidth per 30

XSR(config)#access-list 101 permit udp any any range 16384 32767
XSR(config)#access-list 102 permit udp any any range 20 21

XSR(config)#interface serial 1/0:0
XSR(config-if<S1/0:0>)#frame-relay traffic-shaping
XSR(config-if<S1/0:0>)#interface serial 1/0:0.1 point-to-point
XSR(config-if<S1/0:0.1>)#ip add 10.0.0.1/24
XSR(config-if<S1/0:0.1>)#frame-relay interface-dlci 210
XSR(config-if<S1/0:0.1>)#class VoIP
```

```
XSR(config)#map-class frame-relay VoIP
XSR(config-map-class<VoIP>)#frame-relay cir out 256000
XSR(config-map-class<VoIP>)#frame-relay bc out 25600
XSR(config-map-class<VoIP>)#frame-relay be out 0
XSR(config-map-class<VoIP>)#service-policy output QoS-Policy
XSR(config-map-class<VoIP>)#frame-relay fragment 300
```

QoS with VLAN Policy

The following example configures QoS on a VLAN interface. First, add the class map *cos5To7* with the matching CoS criterion *5 6 7*. Then, create the traffic policy *setCosTo4*, associate it with the class map, set the minimum *bandwidth* guarantee to 50 percent, and specify the output VLAN header priority to *4*. Finally, configure VLAN ID 1200 on GigabitEthernet sub-interface 2.1.

```
XSR(config)#class-map match-any Cos5To7
XSR(config-cmap<Cos5to7>)#match cos 5 6 7
XSR(config-cmap<Cos5to7>)#exit
XSR(config)#policy-map setCosTo4
XSR(config-pmap<setCosTo4>)#class cos5To7
XSR(config-pmap-c<Cos5to7>)#bandwidth percent 50
XSR(config-pmap-c<Cos5to7>)#set cos 4
XSR(config-pmap-c<Cos5to7>)#exit
XSR(config)#interface gigabitethernet 2.1
XSR(config-if<G2.1>)#vlan 1200
XSR(config-if<G2.1>)#ip address 192.168.33.44 255.255.255.0
XSR(config-if<G2.1>)#service-policy output setCosTo4
XSR(config-if<G2.1>)#no shutdown
```

Input and Output QoS Policy

The following example displays how the same policy map may be applied for input and output. With MLPPP, it is used for input QoS and on the Ethernet interface it is used for output QoS policy. Shaping, RED and bandwidth features take no effect on MLPPP.

```
XSR(config)#class-map A
XSR(config-cmap<A>)#match ip DSCP 32
XSR(config-cmap<A>)#match access-group 101
XSR(config-cmap<A>)#exit

XSR(config)#policy-map InOut
XSR(config-pmap<InOut>)#class A
XSR(config-pmap-c<A>)#bandwidth per 20
XSR(config-pmap-c<A>)#shape 100000
XSR(config-pmap-c<A>)#random-detect 10 20 10
XSR(config-pmap-c<A>)#exit
XSR(config-pmap<InOut>)#class class-default
XSR(config-pmap-c<class-default>)#police 50000 2000
XSR(config-pmap-c<class-default>)#exit
XSR(config-pmap<InOut>)#exit
```

```
XSR(config)#interface multilink 1
XSR(config-if<M1>)#service-policy input InOut
XSR(config-if<M1>)#exit

XSR(config)#interface fastethernet 1
XSR(config-if<F1>)#service-policy output InOut
```

Input QoS on Ingress to the Diffserv Domain Policy

If the XSR is positioned on the edge of the diffserv (DS) domain, it must perform edge traffic conditioning required by the diffserv domain for traffic entering from outside the domain. Traffic conditioning on input QoS include marking and policing.

In the following example, the Ethernet interface is situated outside the DS domain. All other XSR interfaces belong to the DS domain. Incoming traffic is classified in three flows: RTP traffic which is marked with the EF code point, traffic flow for destination 10.10.10.0 which is policed to 10 Mbps, and FTP traffic which is policed to 5Mbps with conforming traffic marked with AF=21 and exceeding traffic marked with AF=23. All other traffic is marked with DSCP=0 and policed to 10 Mbps.

```
XSR(config)#class-map RTP
XSR(config-cmap<RTP>)#match access-group 110
XSR(config-cmap<RTP>)#exit
XSR(config)#class-map Dest10
XSR(config-cmap<Dest10>)#match access-group 112
XSR(config-cmap<Dest10>)#exit
XSR(config)#class-map FTP
XSR(config-cmap<RTP>)#match access-group 113
XSR(config-cmap<RTP>)#exit

XSR(config)#access-list 110 permit udp any any eq 3020
XSR(config)#access-list 112 permit tcp any 10.10.10.0 0.0.0.255
XSR(config)#access-list 113 permit tcp any any range 20 21

XSR(config)#policy-map Eht
XSR(config-pmap<Eht>)#class RTP
XSR(config-pmap-c<RTP>)#set ip dscp EF
XSR(config-pmap-c<RTP>)#exit
XSR(config-pmap<Eht>)#class Dest10
XSR(config-pmap-c<Dest10>)#police 10000000 10000
XSR(config-pmap-c<Dest10>)#exit
XSR(config-pmap<Eht>)#class FTP
XSR(config-pmap-c<FTP>)#police 5000000 10000 conform-action set-dscp-transmit 21
exceed-action set-dscp-transmit 23
XSR(config-pmap-c<FTP>)#exit
XSR(config-pmap<Eht>)#class class-default
XSR(config-pmap-c<class-default>)#set ip dscp 0
XSR(config-pmap-c<class-default>)#police 10000000 10000
XSR(config-pmap-c<class-default>)#exit
XSR(config-pmap<Eht>)#exit
```

```
XSR(config)#interface fastethernet 2
XSR(config-if<F2>)#service-policy input Eth
```

13

Configuring ADSL

This chapter details the background, features, implementation and configuration of Asymmetric Digital Subscriber Line (ADSL) on the XSR.

Overview

ADSL (Asymmetric Digital Subscriber Line) is a technology for transmitting digital information at a high bandwidth over existing phone lines. Unlike regular dialup phone service, ADSL provides continuously available, "always on" service.

ADSL is asymmetric in that it uses most of the channel to transmit downstream to the user and a smaller part of the channel to receive information from the user. ADSL simultaneously accommodates analog (voice) information on the same line.

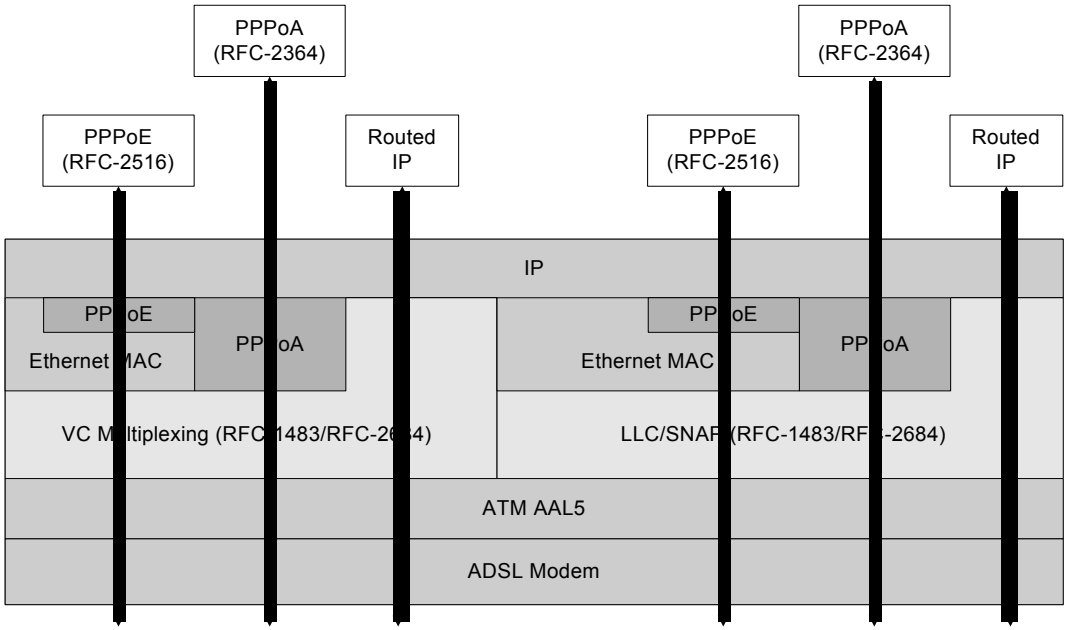
Features

The following ADSL features are supported on the XSR:

- NIM hardware identification via an on-card EEPROM
- ADSL line operation over POTS and ISDN circuits
- ADSL data framing format ATM Frame UNI (FUNI)
- OAM cells: AIS, RDI, CC, Loopback over F4 and F5 flows
- Up to 30 ATM permanent virtual circuits (PVCs)
- ATM UBR traffic class
- ATM Adaptation Layers 0 and 5
- PDU encapsulation types:
  - PPPoE - Point-to-Point Protocol over Ethernet (RFC-2516)
  - PPPoA - Point-to-Point Protocol over ATM)
  - IPoA - Routed IP over ATM (RFC-2684)
- Response to inverse ARP requests
- Maintenance of SNMP interface and Interface Stack Tables
- "Dying Gasp" support to perform an orderly shutdown and report an outage to your DSLAM

Figure 13-1, shown below, illustrates the three "flavors" of ADSL the XSR supports and the path ADSL traffic follows through various encapsulation layers as defined by the pertinent RFCs.

Figure 13-1 RFC Encapsulation Layers



PDU Encapsulation Choices

The XSR's Protocol Data Unit (PDU) encapsulation choices are described and illustrated as follows.

PPP over ATM

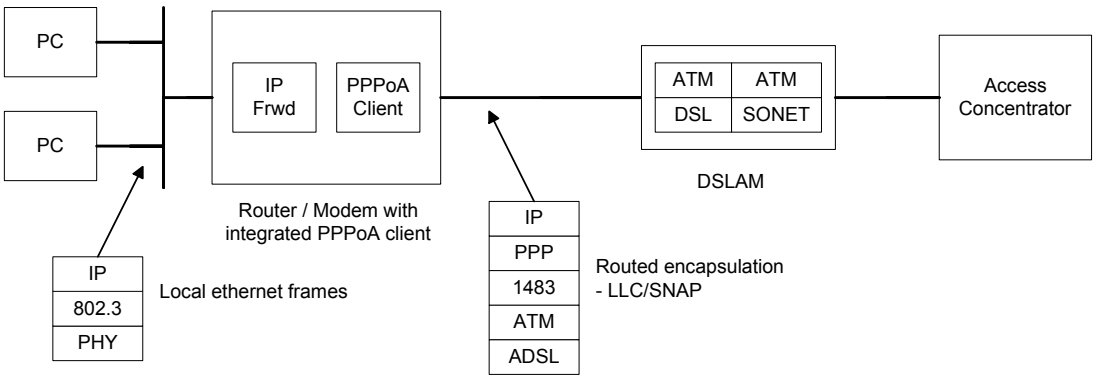
The XSR's PPPoA option, as defined by RFC-2364, supports the following features. The router includes an integrated PPPoA client which adds LLC/SNAP encapsulation to packets headed to the DSLAM, and strips the same from packets headed to its interior networks.

PPPoA is invoked by the **`encapsulation ipoa`** command. As shown in Figure 13-2, PPPoA supports networks running:

- LLC-encapsulated PPP payload over an ATM PVC
- Virtual circuit multiplexed PPP payload over an ATM PVC
- Statically configured and negotiated IP addresses
- Magic Number LCP configuration option

Note: Your choosing the correct PPP encapsulation method depends on the Customer Premises Equipment (CPE) support offered by your DSL provider.

Figure 13-2 PPPoA Network Diagram



This implementation is restricted as follows:

- Maximum MTU of 1500 bytes
- ATM SVCs are not supported
- Frame Relay/ATM internetworking (per FRF.8) is not supported
- PPP coding transitions - switching the method (VC-multiplexed PPP to LLC-encapsulated PPP and back) - are not supported
- PPP will not request the following LCP configuration options:
  - Protocol Field Compression
  - Field Check Sequence Alternatives
  - Address-and-Control-Field-Compression
  - Asynchronous-Control-Character-Map

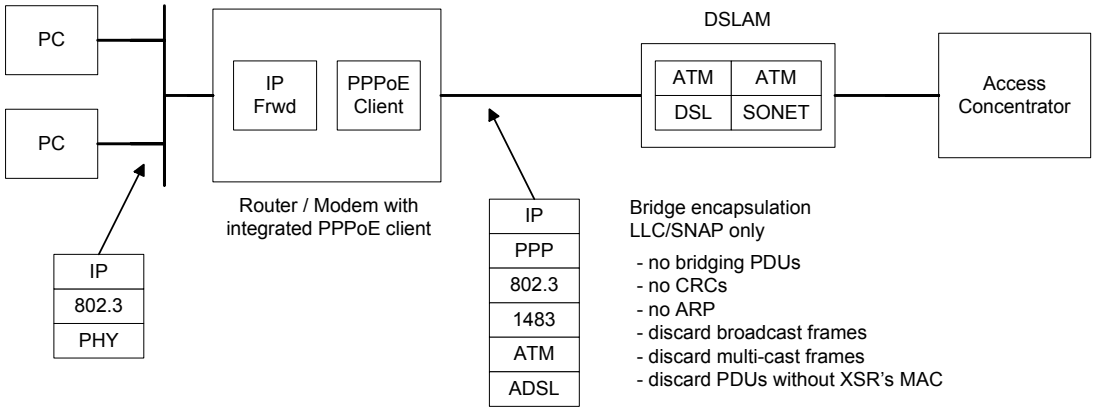
PPP over Ethernet over ATM (Routed)

The XSR's PPPoE option, as shown in Figure 13-3, encapsulates PPP PDUs in the form of Ethernet frames which are encoded as bridged PDUs, as defined by RFC-2684. The router incorporates an integrated PPPoE client which supports the features described below:

- PPPoE encapsulation according to RFC-2516
- PPPoE session management procedures according to RFC-2516
- Bridged Ethernet PDU (802.3) encapsulation according to RFC-2684
- Statically configured and negotiated IP addresses
- Although the XSR does not support bridging protocols and operations, since most ADSL access concentrators support this encapsulation type the XSR implements the IP PDU encapsulation portion of RFC-2684 as required to enable data traffic flows. Essentially, the XSR implementation is an integrated PPPoE client supported over a router, not over a bridge as specified in RFCs 2516 and 2684. PPPoE is invoked by the **`encapsulation pppoe`** command.

Note: Your choosing the correct PPP encapsulation method depends on the Customer Premises Equipment (CPE) support offered by your DSL provider.

Figure 13-3 PPPoE Network Diagram



The limitations of this configuration are as follows:

- Maximum MTU of 1492 bytes
- ARP is not supported
- Other received bridged PDU types are silently discarded (802.4, 802.5, 802.6, FDDI)
- Does not send (PID type 0x00-01) and ignores received (PID type 0x00-01) LAN FCSs
- Spanning tree protocols are not supported
- Any received PDU which does not specify the XSR's MAC address are silently discarded
- The access concentrator must be configured with bridging and ATM ILMI disabled
- ATM SVCs are not supported

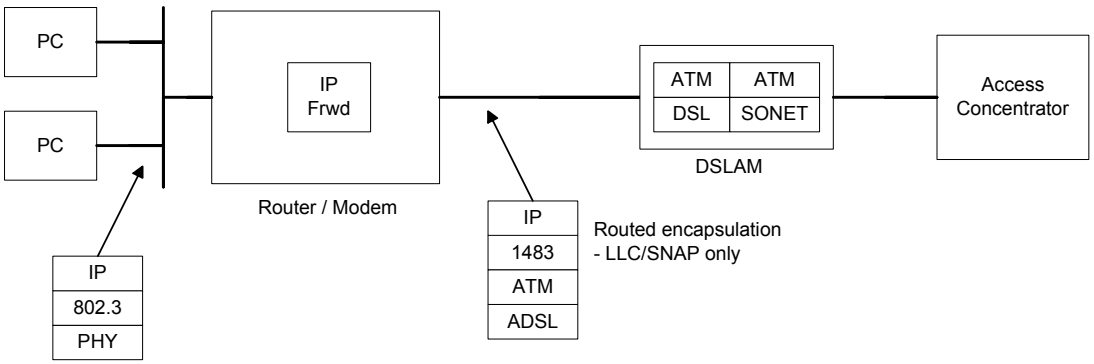
Routed IP over ATM

The XSR's Routed IP over ATM (IPoA) method, as shown in Figure 13-4, supports the following subset of RFC-2684 as it relates to Routed IP PDUs:

- LLC encapsulated routed non-NLPID formatted IP version 4 PDUs over ATM PVCs
- Non-encapsulated routed IP v4 PDUs over ATM PVCs (virtual circuit multiplexing mode)
- Statically configured IP address
- IPoA is invoked by the **`encapsulation ipoa`** command.

Note: Your choosing the correct encapsulation method depends on the Customer Premises Equipment (CPE) support offered by your DSL provider.

Figure 13-4 IP over ATM Network Diagram



Restrictions of this implementation are as follows:

- Maximum MTU of 1500 bytes
- NLPID-formatted routed IP version 4 PDUs over ATM PVCs are not supported
- LLC-encapsulated bridge PDUs are not supported. Any bridged PDUs received and PDUs received which specify a foreign MAC address (not the XSR's) are silently discarded.
- Dynamic IP addresses acquired by DHCP are not supported
- ATM SVCs are not supported

ADSL Limitations

Consider the following caveats regarding ADSL operations on the XSR:

- The standard ADSL configuration reserves circuit 1/33 (VPI/VCI) as the Vendor Specific Channel) per ADSL Forum TR-008
- One Virtual Path *only* is supported
- The maximum overall MTU is 1500 bytes; default is 1492 bytes
- Bridging protocols and operations must be disabled on access concentrators
- ILMI protocols must be disabled on access concentrators
- One ADSL NIM card type is supported per XSR: Annex A or B.
- PPPoE connects to the *first* advertised service name only

ADSL Hardware

NIM Card

Two versions of the ADSL NIM are available for XSR Series 1800 and 3000 routers:

- Version 1 complies with ITU-T Recommendation G.992.1 Annex A - ADSL over POTS (Part #: *NIM-ADSL-AC-01*).
- Version 2 complies with ITU-T Recommendation G.992.1 Annex B - ADSL over ISDN (Part #: *NIM-ADSL-B-01*).

Caution: The XSR supports one installed ADSL NIM card *type* at a time (multiple installed cards must be of the same type).

ADSL on the Motherboard

Two versions of ADSL are provided by the XSR Series 1200 routers:

- Annex A over POTS on the XSR-1220
- Annex B over ISDN on the XSR-1235

DSP Firmware

Digital Signal Processing (DSP) firmware, which the XSR's onboard ADSL modem uses to communicate with your provider's Digital Subscriber Line Access Multiplexer (DSLAM), is stored in the **`adsl.fls`** file on a CompactFlash card shipped with the ADSL NIM on XSR 1800 and 3000 Series routers (it is embedded on the motherboard on XSR Series 1200 routers). When inserted into the Compact Flash slot - upon first configuring an ATM interface - the XSR's ADSL driver copies **`adsl.fls`** into host memory where it will remain available for use on demand. Be aware that if all ATM interfaces are deleted, **`adsl.fls`** must be recopied.

Several CMV commands are provided to "train" the DSP if necessary although it is recommended they be used by Enterasys field personnel *only*. The **`cmv append`** command adds variables to the DSP training list and the **`cmv clear`** command removes all of them. Also, **`cmv cr`** and **`cmv cw`** read and write variables to the DSP, respectively, **`cmv delete`** removes them individually, **`cmv print`** outputs them to the console, and **`cmv save`** copies them to a file.

ADSL Data Framing

The XSR supports the ATM Frame UNI (FUNI) mode of data framing on an ADSL line, as defined by ATM Forum document TR-003.

ATM Frame UNI is a derivative of ATM Data Exchange Interface. Framing is a member of the HDLC family of data link protocols and, in the XSR, uses the same number of header bytes. It uses standard HDLC start and stop flag bytes to guarantee flag recognition and bit-stuffing to achieve data transparency. The ATM FUNI frame header contains address and control fields. The address field encodes the Service Data Unit's (SDU) virtual connection VPI and VCI.

ATM Support

Virtual Circuits

ADSL supports up to 30 ATM Permanent Virtual Circuits (PVCs) over one virtual circuit number. PVCs are configured with the **`pvc vpi/vci`** command.

According to DSL Forum document TR-008, the ADSL interface, by default, provisions a single permanent virtual circuit for data traffic as follows:

- VPI = 1
- VCI = 32

You may configure a different virtual circuit for data traffic.

A second circuit is reserved as the Vendor Specific Channel, as follows:

- VPI = 1
- VCI = 33

Note: This circuit can not be used for any other purpose when operating in FUNI mode.

OAM Cells

OAM cells are messages used to operate, administer, and maintain ATM networks. They provide in-band control functions for virtual circuits, including hop-by-hop and end-to-end functions such as path connectivity and delay measurement. Two distinct varieties exist, types 4 and 5, which usually comprise only a small fraction of the population of cell traffic in a typical ATM switch.

OAM cells are supported for link management as follows:

- CC - *Continuity Check* cells, including negotiation of use. The XSR does not originate CC cells.
- AIS - *Alarm Indication Signal* cells are handled as received, but the XSR does not generate them.
- RDI - *Remote Defect Indication* cells.

Loopback cells are echoed back to the sender. The XSR may be configured to send loopback cells as a keep-alive mechanism with the **`oam-pvc`** and **`oam-retry`** commands.

These cells are supported over F4 (path) and F5 (circuit) flows with the following restrictions:

- End-to-end and segment-type cells are supported.
- Response cells are sent on the flow (F4 or F5) on which the request was received. An AIS cell received on a path (F4 flow) will not result in RDI response cells being sent on each circuit (F5 flow) carried by that path. The circuits however will be put in the operational down state (data will not flow) until the AIS state has been terminated.

Performance Monitoring

Cell error counts are maintained on statistics supplied by the ADSL processor. Use the **`show controllers atm`** and **`show interface atm`** commands to display ADSL statistics.

Class of Service

The XSR's ADSL interface supports the UBR traffic class only.

DSLAM Compatibility

The XSR's ADSL functionality is compatible with many deployed DSLAMs. Refer to your sales representative for more information.

Access Concentrator Restrictions

Consider the following restrictions for access concentrator configuration:

- All bridging protocols and operations must be disabled. Any non-user data PDUs received by the ADSL port are silently discarded.
- ILMI protocols and operations must be disabled. Any ILMI traffic received by the ADSL port are silently discarded.

Inverse ARP

The XSR employs Inverse ARP as defined in RFC-1293 with modifications specified by RFC-2225 (Classical IP over ATM). Inverse ARP is supported for PVCs which are configured as Routed IPv4 circuits (per RFC-1483), using LLC/SNAP encapsulation. This implementation will not send an ATM hardware address and addresses received will be discarded. Only the IP address is used.

The XSR will respond to but not send Inverse ARP requests.

QoS

The XSR supports QoS functionality over an ADSL line.

SNMP

The ADSL interface creates and maintains entries in the Interface Table as required by NetSight. Entries will be made in the table for the following:

- ADSL Driver
- ATM Interface
- ATM Sub-Interface
- IP Interface
- PPP (when configured)

Configuration Examples

The following examples describe PPPoE, PPPoA, and IPoA configuration scenarios. When configuring PPPoE for the first time, be sure to insert the DSP CompactFlash card in the CompactFlash slot (refer to the *XSR Getting Started Guide* for further instructions).

Note: ADSL configuration on XSR 1200 Series routers is significantly different than for XSR 1800 and 3000 routers. For example, only interfaces **`FastEthernet 0:<1-2>.<1-30>`** and **`ATM 0.<1-30>`** are configurable on the XSR 1200 Series. For more information, refer to the *XSR 1220/1235 Getting Started Guide*.

PPPoE

The following commands configure a sample PPPoE topology. The first set configures the LAN interface with directed broadcasts prohibited..

Note: All ATM examples in this chapter reference Ethernet interfaces on XSR 1800/3000 Series routers.

```
XSR(config)#interface FastEthernet1
XSR(config-if<F1>)#ip address 192.168.1.1 255.255.255.0
XSR(config-if<F1>)#no ip directed-broadcast
XSR(config-if<F1>)#no shutdown
```

The commands below configure the ATM interface and sub-interface with a negotiated IP address, PAP username and password, and ban keepalives. They also reset default PVC VPI and

VCI values to those requested by the DSL provider. Notice that the Maximum Segment Size (MSS) is set to 1400 bytes for TCP SYN (synchronize) packets. Because a PC connected to a Fast/GigabitEthernet port may be unable to access Web sites if its MSS setting is too high, subtracting for the PPPoE, IP, TCP, and GRE headers (6, 20, 20, and 24 bytes, respectively) and the PPP Protocol ID should avoid that problem.

```
XSR(config)#interface ATM 1/0
XSR(config-if<ATM1/0>)#no shutdown
XSR(config-if<ATM1/0>)#interface ATM 1/0.1
XSR(config-if<ATM0/1/0.1>)#no shutdown
XSR(config-if<ATM0/1/0.1>)#encapsulation mux pppoe
XSR(config-if<ATM0/1/0.1>)#ip address negotiated
XSR(config-if<ATM0/1/0.1>)#ip mtu 1492
XSR(config-if<ATM0/1/0.1>)#ip tcp adjust-mss 1400
XSR(config-if<ATM0/1/0.1>)#ppp pap sent-username user@net password letmein
XSR(config-if<ATM0/1/0.1>)#no ppp keepalive
XSR(config-if<ATM0/1/0.1>)#pvc 0/100
```

Note: If you have configured a VPN tunnel and wish to avoid intermittent Web browser problems, add the `crypto ipsec df-bit clear` command to your configuration.

The following *optional* commands configure two default routes:

```
XSR(config)#ip route 0.0.0.0 0.0.0.0 30.0.0.10
XSR(config)#ip route 30.0.0.10 255.255.255.255 ATM 1/0.1
```

The following *optional* commands configure NAT:

```
XSR(config)#access-list 99 permit 192.168.1.0 0.0.0.255
XSR(config)#interface FastEthernet1
XSR(config-if<F1>)#ip nat source list 99 assigned overload
```

PPPoA

Enter the following commands to configure PPPoA. The first set configures the LAN interface with directed broadcasts prohibited.

```
XSR(config)#interface FastEthernet1
XSR(config-if<F1>)#ip address 192.168.1.1 255.255.255.0
XSR(config-if<F1>)#no ip directed-broadcast
XSR(config-if<F1>)#no shutdown
```

The commands below configure the ATM interface and sub-interface with a negotiated IP address, CHAP username and password, and bans keepalives.

```
XSR(config)#interface ATM 1/0
XSR(config-if<ATM1/0>)#no shutdown
XSR(config-if<ATM0/1/0.1>)#interface ATM 1/0.1
XSR(config-if<ATM0/1/0.1>)#no shutdown
XSR(config-if<ATM0/1/0.1>)#encapsulation snap pppoa
XSR(config-if<ATM0/1/0.1>)#ip address negotiated
XSR(config-if<ATM0/1/0.1>)#ip mtu 1492
XSR(config-if<ATM0/1/0.1>)#ip tcp adjust-mss 1400
XSR(config-if<ATM0/1/0.1>)#ppp chap hostname red password sox
XSR(config-if<ATM0/1/0.1>)#no ppp keepalive
```

The following *optional* command configures a universal default route:

```
XSR(config)#ip route 0.0.0.0 0.0.0.0 atm 1/0.1
```

IPoA

Enter the following commands to configure a IPoA topology:

```
XSR(config)#interface ATM 1/0
XSR(config-if<ATM1/0>)#no shutdown
XSR(config-if<ATM1/0>)#interface ATM 1/0.1
XSR(config-if<ATM0/1/0.1>)#encapsulation snap ipoa
XSR(config-if<ATM0/1/0.1>)#ip address 192.168.1.1 255.255.255.0
XSR(config-if<ATM0/1/0.1>)#ip mtu 1492
XSR(config)#ip route 0.0.0.0 0.0.0.0 30.0.0.10
XSR(config)#ip route 30.0.0.10 255.255.255.255 ATM 1/0.1
```

14

Configuring the Virtual Private Network

VPN Overview

As it is most commonly defined, a Virtual Private Network (VPN) allows two or more private networks to be connected over a publicly accessed network. VPNs share some similarities with Wide Area Networks (WAN), but the key feature of VPNs is their use of the Internet rather than reliance on expensive, private leased lines. VPNs boast tighter security and encryption features as a private network, while taking advantage of the economies of scale and remote accessibility of large public networks.

Internet Security Issues

All communication over the Internet uses the Transmission Control Protocol/Internet Protocol (TCP/IP) or User Datagram Protocol (UDP). They convey packets from one computer to another through a variety of intermediate computers and separate networks before they reach their destination.

TCP/IP's great flexibility has led to its worldwide acceptance as the basic Internet and intranet communications protocol. But, the fact that TCP/IP allows traffic to pass through intermediate computers allows third parties to interfere with communications in the following ways:

- *Eavesdropping* - Information remains intact, but its privacy is compromised. For example, someone could learn your credit card number, record a sensitive conversation, or intercept classified data.
- *Tampering* - Information in transit is changed or replaced and then sent on to the recipient. For example, someone could alter an order for goods or change a person's resume.
- *Impersonation* - Information passes to a person who poses as the intended recipient. Impersonation can take two forms:
  - *Spoofing* - A person can pretend to be someone else. For example, a person can pretend to have the email address **`jdoe@acme.com`**, or a computer can identify itself as a site called **`www.acme.com`** when it is not. This type of impersonation is known as spoofing.
  - *Misrepresentation* - A person or organization can misrepresent itself. For example, suppose the site **`www.acme.com`** pretends to be a furniture store when it is really just a site that takes credit-card payments but never sends any goods.

Normally, users of the many cooperating computers that comprise the Internet or other networks do not monitor or interfere with network traffic that continuously passes through their machines. But, sensitive personal and business communications over the Internet require precautions that address potential threats. Fortunately, a set of well-established techniques and standards aggregated under Internet Protocol Security (IPSec)/Internet Key Exchange (IKE) and the Public-Key Infrastructure protocol (PKI) make it relatively easy to take such precautions.

The combined features of the above protocols facilitate the following tasks:

- *Encryption and decryption* promote confidentiality by allowing two communicating parties to disguise information they share. The sender encrypts, or scrambles, data before sending it. The receiver decrypts, or unscrambles, the data after receiving it. While in transit, the encrypted information is unintelligible to an intruder.
- *Tamper detection* ensure data integrity by permitting the recipient of data to verify that it has not been modified in transit. Any attempt to modify data or substitute a false message for a legitimate one will be detected. A hash value is calculated by the sender every time data is sent, and calculated when data is received, and both values are compared.
- *Authentication* allows the recipient of data to determine its origin - that is, to confirm the sender's identity by digitally signing a message or applying the challenge-response method.
- *Nonrepudiation* prevents the sender of information from claiming at a later date that the information was never sent.

A later section of this chapter details the XSR's security implementation.

How a Virtual Private Network Works

VPNs provide an advanced combination of tunneling, encryption, authentication and access control technologies and services to carry traffic over the Internet, a managed IP network or a provider's backbone.

Traffic reaches these backbones using any combination of access technologies, including Ethernet, T1, Frame Relay, ISDN, or simple dial access. VPNs use familiar networking technology and protocols. The client sends a stream of encrypted packets to a remote server or router, except instead of going across a dedicated line (as in the case of WANs), the packets traverse a tunnel over a shared network.

The initial idea behind using this method was for a company to reduce its recurring telecommunications charges that are shouldered when connecting remote users and branch offices to resources at a firm's headquarters.

Using this VPN model, packets headed toward the remote network will reach a tunnel initiating device, which can be anything from an extranet router to a laptop PC with VPN-enabled dial-up software. The tunnel initiator communicates with a VPN terminator, or a tunnel switch, to agree on an encryption scheme. The tunnel initiator then encrypts the package for security before transmitting to the terminator, which decrypts the packet and delivers it to the appropriate destination on the network.

The XSR provides Remote Access support for the connection of remote clients and gateways in a topology where PPTP or L2TP protocols are employed. The XSR also provides Site-to-Site tunnel support in a topology where routers occupy each end of a connection. Site-to-site tunnels, also known as peer-to-peer tunnels, employ IPSec as the main security provider.

The XSR's site-to-site connectivity allows a branch office to divest multiple private links and move traffic over a single Internet connection. Since many sites use multiple lines, this can be a very useful application, and it can be deployed without adding additional equipment or software.

Ensuring VPN Security with IPSec/IKE/GRE

The key word in Virtual Private Networks is private. To ensure the security of sensitive corporate data, the XSR relies chiefly on IPSec, the standard framework of security protocols. IPSec is not a single protocol but a suite of protocols providing data integrity, authentication and privacy.

Since IPSec is the standard security protocol, the XSR can establish IPSec connections with third-node devices including routers as well as PCs. An IPSec tunnel basically acts as the network layer protecting all data packets that pass through, regardless of the application or device.

The XSR makes it possible to control the type of traffic sent over a VPN by allowing you to define group-based filters (Access Control Lists) which control IP address and protocol/port services allowed through the tunnel. An IPSec-based VPN also permits you to define a list of specific networks and applications to which traffic can be passed.

Central to IPSec is the concept of the Security Association (SA). A primary role of IKE is to establish and maintain SAs by its use of the IP Authentication Header (AH) or Encapsulating Security Payload (ESP). An SA is a uni-directional logical connection between two communicating IP endpoints that applies security to the traffic carried by it using the AH or ESP features listed in a transform-set (described below).

The endpoint of an SA can be an IP client (host) or IP security gateway. Providing security for the more typical scenario of bi-directional communication between two endpoints requires the establishment of two SAs (one in each direction). An SA is uniquely identified by the following:

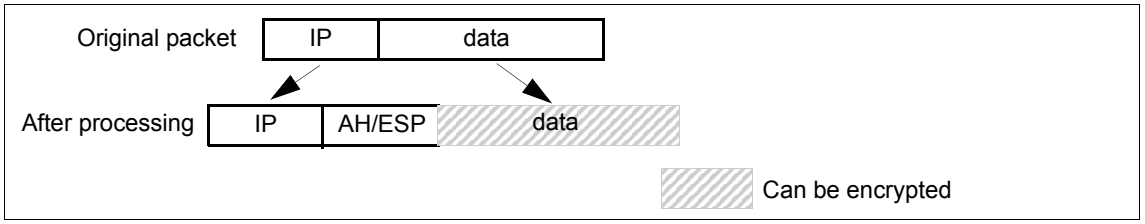
- A 32-bit identifier of the connection
- The IP destination address
- A security protocol identifier (AH or ESP)

The IP Authentication Header (AH), defined in RFC-2402, checks for data integrity, data origin authentication, and replay on IP packets using HMAC with MD5 (RFC-2403), or HMAC with SHA-1 (RFC-2404).

The IP Encapsulating Security Payload (ESP), described in RFC-2406, performs confidentiality in addition to integrity and authentication checks, but it does not check the integrity of the IP header. As in AH, ESP uses HMAC with MD5 or SHA-1 authentication (RFC-2403/2404); privacy is provided using DES-CBC (RFC-2405), 3DES or AES encryption.

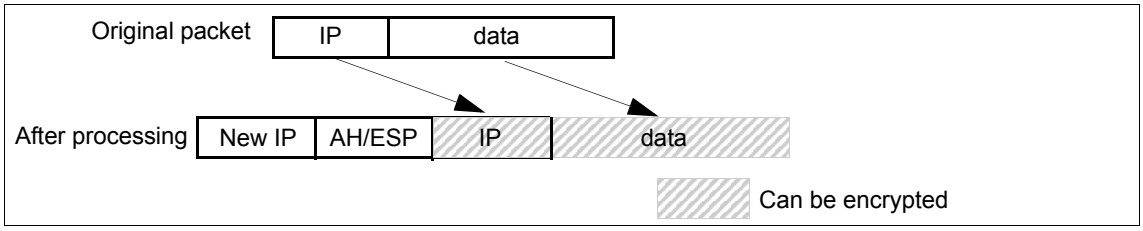
Two types of *modes* are defined in IPSec, *tunnel* and *transport.* At the packet level, transport mode leaves the original IP header intact and inserts AH or ESP headers after the original IP header as shown in Figure 14-1 below.

Figure 14-1 Transport Mode Processing



Tunnel mode adds a new IP header and encapsulates the original IP packet as shown in Figure 14-2.

Figure 14-2 Tunnel Mode Processing



As shown above, AH authenticates the entire packet transmitted on the network whereas ESP only covers a portion of the packet transmitted (the higher layer data in transport mode and the entire original packet in tunnel mode). The ramifications of this difference in the scope between ESP and AH are significant.

Using IPSec along with Network Address Translation (NAT) might be problematic because while AH is used to ensure that the packet header is not changed during transmission, NAT does the opposite - it changes the IP or layer 4 (UDP or TCP) header. AH cannot be used when NAT must be crossed to reach the other end of the tunnel. When only ESP is used, the XSR automatically adds the UDP header which is required by NAT to operate properly when an unroutable address (NAT traffic) is detected between tunnel endpoints.

Arguably the most vital component of IPSec/IKE is the establishment of SAs and key management. Although these tasks can be done manually, the XSR deploys IPSec through a scalable, automated SA/key management scheme known as the Internet Key Exchange (IKE), defined in RFC-2409. This algorithm is the default automated key management, dynamic SA-creating protocol for IPSec.

Refer to Table A-4 on page A-1 for the number of ISAKMP and IPSec SAs supported, by installed memory, on the XSR.

GRE over IPSec

As an alternative to IPSec, the XSR supports the Generic Routing Encapsulation protocol (GRE), which encapsulates arbitrary protocols in other protocols such as IP, as defined by RFC-1701. GRE can tunnel these payloads between two routers over a network path that does not natively support the payload protocol. For example, Appletalk packets can be tunneled in IP over the Internet.

GRE tunnel endpoints are represented as point-to-point (P2P) interfaces to the routing protocols. End-to-end traffic and routing protocol traffic flows through these interfaces as through physical network interfaces. The GRE tunnel encapsulates entire frames so it can carry multicast packets across the tunnel between two routers. This supports routing protocols such as OSPF.

GRE does not provide security but can be encrypted and authenticated by the XSR's IPSec subsystem. GRE packets are transmitted using IPSec *transport* mode. GRE with IPSec provides multiprotocol and multicast tunneling with strong security. Because GRE lacks a control over tunnel establishment, both sides of the tunnel must have known IP addresses, not dynamically assigned. Refer to "GRE Tunnel for OSPF" on page 14-40 for an example.

Note: GRE tunnel interfaces support P2P links only with other routers.

Defining VPN Encryption

To ensure that the VPN is secure, limiting user access is only one piece of the puzzle; once the user is authenticated, the data itself needs to be protected as well. Without a mechanism to provide data privacy, information flowing through the channel will be transmitted in clear text, which can easily be viewed or stolen with a packet sniffer.

The type of encryption available is highly varied but there are two basic cryptographic systems: *symmetric* and *asymmetric*. Symmetric cryptography tends to be much faster to deploy, are commonly used to exchange large volumes of data between two parties who know each other, and use the same private key to encrypt and decrypt data.

Asymmetric systems (public-key) are more complex and require a pair of mathematically related keys - one public and one private (known only to the recipient). This method is often used for smaller, more sensitive packets of data, or during the authentication process.

Generally, longer encryption keys are stronger. An algorithm's bit length determines the amount of effort required to crack the system using a *brute force* attack, where computers are combined to calculate all the possible key permutations. The XSR offers several encryption schemes:

- *Data Encryption Standard* (DES): a 20-year old, thoroughly tested system that uses a complex symmetric algorithm with a 56-bit key, but is considered less secure than recent systems.
- *Triple DES* (3DES): uses three DES passes and an effective key length of 168 bits, thus strengthening security.
- *Diffie-Hellman*: the first public-key cryptosystem, is used to generate asymmetric (secret) keys, not encrypt and decrypt messages.
- *Advanced Encryption Standard* (AES): the anticipated replacement for DES, supports a 128-bit block cipher using a 128-, 192-, or 256-bit key.
- *RSA signatures*: an asymmetric public-key cryptosystem used for authentication by creating a digital signature.

Describing Public-Key Infrastructure (PKI)

PKI is a scalable platform for secure user authentication, data confidentiality, integrity, and non-repudiation. It can be applied to allow users to use insecure networks in a secure and private way. PKI relies on the use of public key cryptography, digital certificates, and a public-private key pair.

Digital Signatures

Encryption and decryption address eavesdropping, one of the three Internet security issues mentioned at the beginning of this chapter. But encryption and decryption, by themselves, do not address tampering and impersonation.

Tamper detection and related authentication techniques rely on a mathematical function called a one-way *hash* (also called a message digest). A one-way hash is a number of fixed length with the following characteristics:

- The hash value is unique for the hashed data. Any change in the data, even deleting or altering a single character, results in a different value.
- The content of the hashed data cannot, for all practical purposes, be deduced from the hash - which is why it is called *one-way*.

It is possible to use your private key for encryption and public key for decryption. Although this is not desirable when you are encrypting sensitive data, it is a crucial part of digitally signing any

data. Instead of encrypting the data itself, the signing software creates a one-way hash of the data, then uses your private key to encrypt the hash. The encrypted hash, along with other information, such as the hashing algorithm, is known as a digital signature.

Certificates

A certificate is an electronic document to identify an individual, server, company, or other entity and associate that identity with a public key. Like a driver's license, a passport, or other personal IDs, a certificate provides proof of a person's identity. PKI uses certificates to address the problem of impersonation. Certificates are similar to these familiar forms of ID.

Certificate Authorities (CAs) validate identities and issue certificates. They can be either independent third parties or organizations running their own certificate-issuing server software. The XSR supports the Microsoft CA.

The methods used to validate an identity vary depending on the policies of a given CA - just as the methods to validate other forms of identification vary depending on who is issuing the ID and the purpose for which it will be used. In general, before issuing a certificate, the CA must use its published verification procedures for that type of certificate to ensure that an entity requesting a certificate is in fact who it claims to be.

The certificate issued by the CA binds a particular public key to the name of the entity the certificate identifies (such as an employee or server name). Certificates help prevent the use of fake public keys for impersonation. Only the public key certified by the certificate will work with the corresponding private key possessed by the entity identified by the certificate.

In addition to a public key, a certificate always includes the name of the entity it identifies, an expiration date, the name of the CA that issued the certificate, a serial number, and other data. Most importantly, a certificate always includes the digital signature of the issuing CA. The CA's digital signature allows the certificate to function as a *letter of introduction* for users who know and trust the CA but don't know the entity identified by the certificate.

> **Caution:** We recommend that you do not enroll more certificates than permitted by the 1.5 MByte system limit imposed on the **`cert.dat`** file. Doing so may render the XSR unstable and require you to delete the file.

Machine Certificates for the XSR

Certificates can be used by the IKE subsystem to establish SAs for IKE/IPSec tunneling. Key data in the certificates is used to identify other IPSec clients to the XSR and vice versa. In order to utilize certificates on the XSR you must manually collect the certificates for one or more CAs (depending on your configuration) and enroll a certificate for the router. Certificates for CAs identified as CA certificates and certificates representing an IPSec client are identified as IPSec client certificates.

The XSR uses the SCEP protocol to retrieve certificates for the XSR and any CA that may exist in the XSR's or peer's certificate chain.

> **Note:** MS Windows SCEP service delivered with the Windows 2000 OS requires updating to the latest Microsoft patch for SCEP.

Certificate Revocation Lists (CRLs) are used to ensure that both the XSR and any peer certificate are currently valid. CRLs list all certificates that have been revoked by CAs before their natural expiration occurs. The XSR must validate every IPSec certificate it uses against current CRLs available from CAs in the IPSec client certificate chain.

CRL checking is not optional. CRLs are collected automatically by the XSR using information available in the IPSec and CA certificates it has already collected.

Two methods are available to perform this collection:

- HTTP Get issues an HTTP-based request to collect the certificate.
- LDAP issues URL requests to collect CRLs.

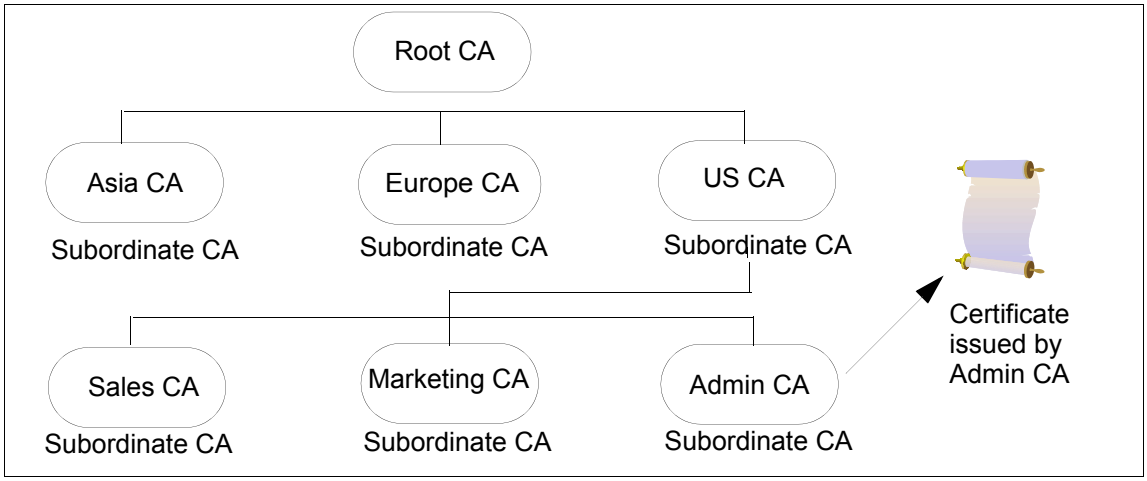
Most CAs can be configured to use either or both of these CRL retrieval mechanisms. The XSR automatically uses one method or the other based on information stored in the certificates.

CA Hierarchies

In large organizations, it may be advantageous to delegate the responsibility for issuing certificates to several different CAs. For example, the number of certificates required may be too large for a single CA to maintain; different organizational units may have different policy requirements; or it may be important for a CA to be physically located in the same geographic area as the people to whom it is issuing certificates.

It is also possible to delegate certificate-issuing responsibilities to subordinate CAs. The X.509 standard includes a model for setting up a hierarchy of CAs. As shown in Figure 14-3, the root CA is at the top of the hierarchy. The root CA's certificate is a self-signed certificate: that is, the certificate is digitally signed by the same entity - the root CA - that the certificate identifies.

Figure 14-3 Sample Hierarchy of CAs

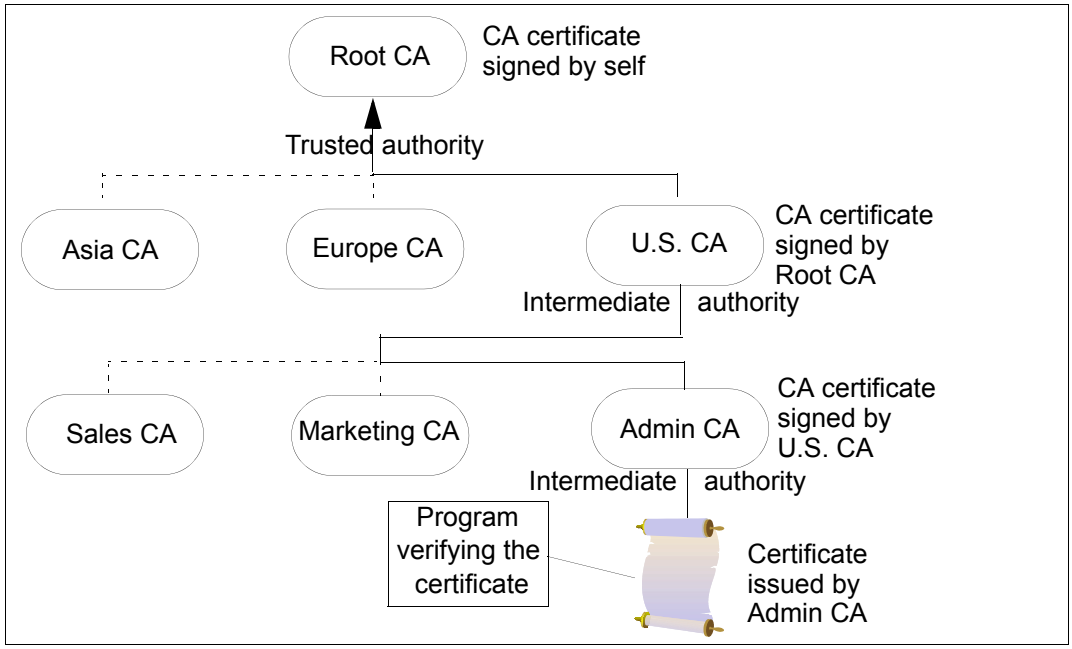


The CAs that are directly subordinate to the root CA have CA certificates signed by the root CA. CAs under the subordinate CAs in the hierarchy have their CA certificates signed by the higher-level subordinate CAs.

Certificate Chains

CA hierarchies are reflected in certificate chains. A certificate chain is series of certificates issued by successive CAs. Figure 14-4 shows a certificate chain leading from a certificate that identifies some entity through two subordinate CA certificates to the CA certificate for the root CA (based on the CA hierarchy shown in Figure 14-4).

Figure 14-4 Certificate Chain Example



A certificate chain traces a path of certificates from a branch in the hierarchy to the root of the hierarchy. In a certificate chain, the following occurs:

- Each certificate is followed by the certificate of its issuer.
- Each certificate contains the name of that certificate's issuer, which is the same as the subject name of the next certificate in the chain.

  In Figure 14-4, the Admin CA certificate contains the name of the CA (that is, US CA) that issued that certificate. USA CA's name is also the subject name of the next certificate in the chain.
- Each certificate is signed with the private key of its issuer. The signature can be verified with the public key in the issuer's certificate, which is the next certificate in the chain.

  In Figure 14-4, the public key in the certificate for the U.S. CA can verify the U.S. CA's digital signature on the certificate for the Admin CA.

The XSR will automatically verify the certificate chain structure associated with any IPSec client certificate once it manually collects certificates for all CAs in the chain. This includes the chain that exists for the certificate enrolled by the XSR and chains for any IPSec peer who will establish tunnels with the router. They must be collected manually but are automatically chained together using information in the CA Client certificates. You do not have to manually create these chains.

CA certificates are stored in a local certificate database. The XSR's IPSec client certificate is enrolled in a CA with **`SCEP enroll`** and stored in the local certificate DB. Certificates for peer IPSec clients are passed to the XSR by IKE, used to authenticate the peer, then discarded.

RA Mode

Some CA implementations distribute the CA's operation/authentication of clients to RA agents - the Microsoft CA implements its CA this way. The XSR will automatically adjust to the CA's mode of operation: you need not specify whether your CA uses RA mode or not. If your CA uses RA mode you will notice more than one certificate for the CA after you authenticate against it.

Pending Mode

Once you have authenticated against the parent CA in your XSR certificate chain, you then enroll the XSR's IPSec client certificate against the CA using the SCEP enroll command. Depending on how your CA administrator has configured the CA, you may or may not immediately receive your IPSec client certificate when you first enroll. If the CA has been configured to use pending mode, the CA administrator must manually issue or deny your request. The CA administrator may take certain steps to verify that the enrollment request is valid, such as calling the system administrator. This process may take a number of hours or days.

When pending mode is configured, the XSR will log that the operation is pending, and will automatically poll for the certificate three times at five-minute intervals. The number of polls and the interval between polls is adjustable using CLI commands under Crypto Identity configuration mode. This assumes that the CA administrator will issue or deny the XSR enrollment request within a 15-minute window.

Once retries are exhausted, the enrollment becomes invalid and you must enroll again. Each poll request and its result are logged in detail by the XSR. Ask your CA administrator what these values should be.

Enroll Password

Another way to validate an enrollment request is to ask the CA administrator to issue a specific password for enrollment. This can either be done manually or through a Web page at the CA. If you are required to provide a specific password for the enrollment, you must use that password or your enrollment will fail. If you are allowed to create your own password, be sure to remember it because it is required if you ever wish to revoke a certificate.

CRL Retrieval

As mentioned earlier, a CRL must be retrieved for any IPSec client certificate the XSR uses for authentication. This is done automatically by the
XSR whenever a new certificate is encountered and on a maintenance cycle that by default occurs every 60 minutes. Depending on your CA's configuration, you may want to adjust how frequently your maintenance task runs. Ask your CA administrator what this value should be set to.

Renewing and Revoking Certificates

A certificate has an expiration date. Additionally, certificates can be revoked at the CA before their expiration time is reached. When a certificate expires, the XSR must be re-authenticated for CA certificates or re-enrolled for its IPSec client certificate: this is not an automatic process.

Only the CA administrator can revoke a certificate - the password used to create the certificate during enrollment is required to revoke it. Revoked certificates will appear in the next CRL. Discuss these periods and strategies with your CA administrator.

DF Bit Functionality

The XSR’s DF bit override feature with IPSec tunnels configures the setting of the DF bit when encapsulating tunnel mode IPSec traffic. If the DF bit is set to clear, the XSR can fragment packets regardless of the original DF bit setting. The DF (Don't Fragment) bit within the IP header determines whether a router is allowed to fragment a packet.

This feature specifies whether the router can *clear*, *set*, or *copy* the DF bit in the encapsulating header. It is available only for IPSec *tunnel* mode - transport mode is not affected because it does not have an encapsulating IP header. Typical enterprise DF bit settings include hosts which perform these roles:

- Use firewalls to block Internet Control Message Protocol (ICMP) "unreachable" errors from outside the firewall, preventing hosts from learning about the Maximum Transmission Unit (MTU) size outside the firewall and causing the originating application to eventually fail
- Set the DF bit in packets they send
- Use IPSec to encapsulate packets, reducing the available MTU size because it is too large for the tunnel's interface. When the encrypted packet header is dropped, along with the DF bit setting, then large packets are dropped, causing instability and likely failure of the tunnel

If your topology includes hosts which screen knowledge of the available MTU size you can set the XSR to clear the DF bit and fragment the packet.

Refer to "XSR with VPN - Central Gateway" on page 14-36 for a sample configuration.

> **Note:** DF bit can be configured globally or per interface. If both levels are configured, Interface will override Global mode. Also, it is supported on any interface on which VPN can be configured.

VPN Applications

The XSR supports the following applications:

- *Site-to-Site* (Peer-to-Peer) - XSRs establish connections between each other, ANG-1102/1105s, 7000s, or third-node devices via the Internet based on certificates and pre-shared keys. This is the simplest tunnel to set up but its functionality set is not as rich as a Site-to-Central tunnel.
- *Site-to-Central-Site* - XSRs, one acting as a central site and the other as a remote site in *Client* or *Network Extension Mode* build links between each other based on pre-shared keys or certificates. The XSR, working as a central site can also terminate tunnels initiated by ANG-1102/1105 and 7000s. This type of tunnel offers several advantages over a Site-to-Site tunnel including:
  - RIP or OSPF routing is supported
  - Tunnel heartbeats are supported
  - Tunnel failover is consistently supported
  - Tunnels are more easily scalable in multiple router topologies
  - Network management is more robust
- *Remote Access* - XSR functions as a tunnel server, establishing dial-up connections with clients over the Internet via local ISPs.

The XSR supports multiple combinations of the above applications and includes auxiliary functionality such as:

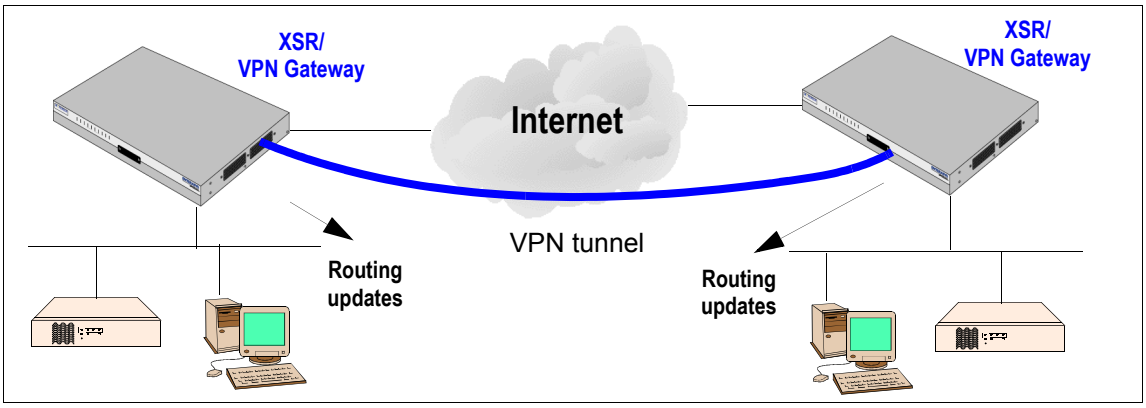
- RADIUS authentication
- PKI authentication
- NAT traversal
- IP address management
- DF Bit override on IPSec tunnels

Site-to-Site Networks

Site-to-site tunnels run as point-to-point links. They are useful when connecting geographically dispersed network segments where each segment contains servers and hosts. VPN tunnels play the role of point-to-point links and are transparent from a routing perspective.

Figure 14-5 shows a link between two XSR sites, but this architecture can be extended to link many sites by creating a mesh topology. While it is extremely flexible for mesh networks, site-to-site is also useful within a hub-and-spoke topology.

Figure 14-5 VPN Site-to-Site Topology



VPN gateways terminating a tunnel cannot run routing protocols, therefore must solely rely on static routes. Only packets destined for networks behind the peer will be encrypted and shipped via a tunnel. Other traffic will either be dropped or forwarded to the Internet depending on your security policy.

Authentication for IPSec tunnels can be performed using pre-shared keys or certificates. Authentication using pre-shared keys is acceptable in this application because the number of connected peers is relatively small.

This type of tunnel follows IETF standards and is interoperable with other vendors' devices. The IPSec portion of a GRE/IPSec tunnel is this type of Peer-to-Peer/Site-to-Site configuration. Refer to "Configuring a Simple VPN Site-to-Site Application" on page 14-32 and "Configuration Examples" on page 14-36 for detailed Site-to-Site setups.

Site-to-Central-Site Networks

In a Site-to-Central-Site application, tunnel nodes are *not* equivalent. One node initiates a tunnel, the other accepts it. In practice, the initiating node represents the smaller client entity and connects to the *bigger* corporate network through the server.

NAT Traversal

Since the connection is always initiated by the client site, it can reside behind an ISP-operated NAT device. But, the presence of NAT requires the IPSec feature known as *NAT traversal* since routers/VPN gateways which terminate tunnels cannot reside behind a NAT device because external addresses must be valid, routable addresses. This factors into a site-to-site tunnel scenario where both XSRs play an *equivalent* role and any VPN gateway can initiate a tunnel.

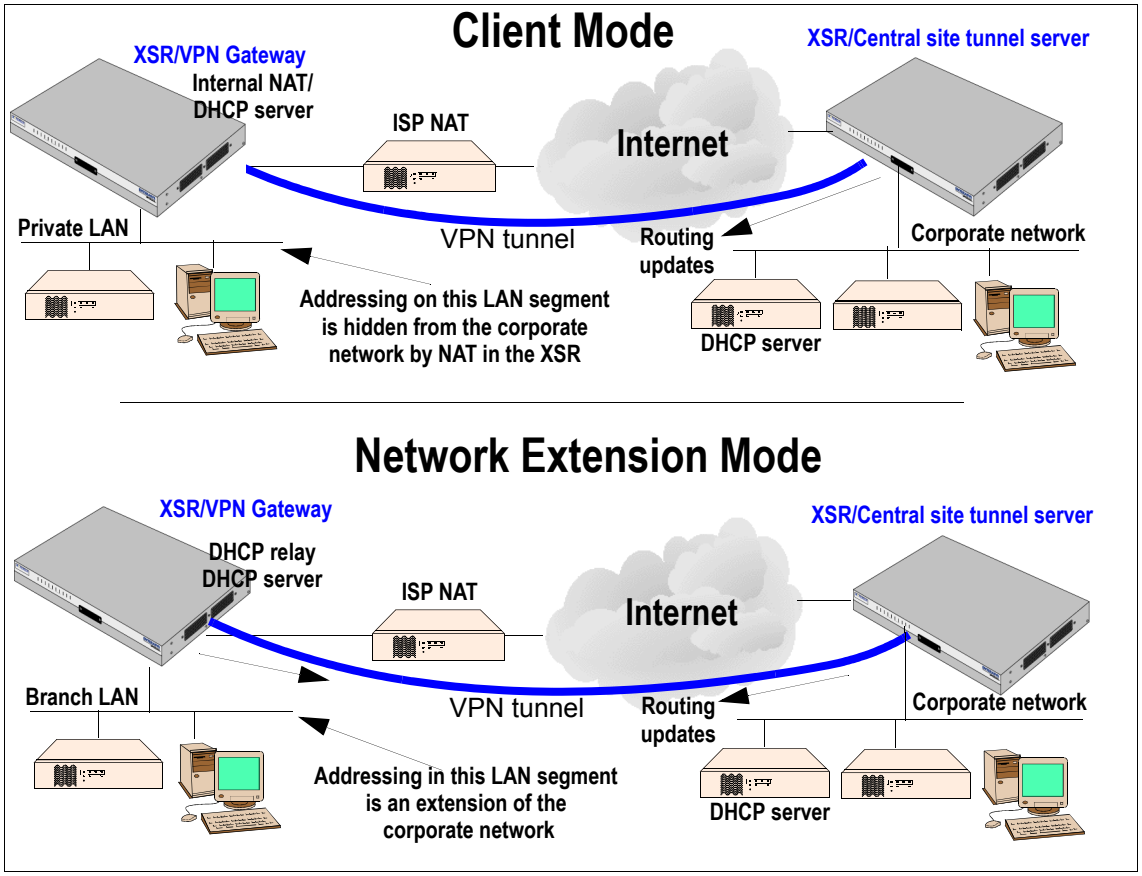
Beginning with Release 7.0, the XSR supports NAT traversal according to *draft-ietf-ipsec-nat-t-ike-02*. The XSR sends IKE messages from UDP port 4500 when 1), a NAT device is present between IKE peers and 2), the peer has implemented *draft-ietf-ipsec-nat-t-ike-02.*

If you filter traffic with ACLs, you will need to write an ACL similar to this example: **`access-list 101 permit udp any host 192.168.57.4 eq 4500`**. If you enable the XSR firewall, refer to "Configuring Security on the XSR" on page 16-1 for more information. You can verify traffic is passing the NAT device by entering the **`show crypto ipsec sa`** command. It displays the following sample output, citing Port *4500* and *UDP-encaps*(ulation).

```
63.81.64.58/32, UDP, 1701  ==>  63.81.64.89/32, UDP, 1701 : 490 packets
ESP: SPI=6723a3c3, Transform=3DES/HMAC-SHA, Life=2384S/249895KB
Local crypto endpt.=63.81.64.89:4500, Remote crypto endpt.=63.81.64.58:20002
Encapsulation=Transport UDP-Encaps
```

Depending on the type of IP address management configured on the connecting site of this application, site-to-central-site networks can be built two ways, as shown in Figure 14-6.

Figure 14-6 Site-to-Central-Site Topology



Client Mode and Network Extension Mode tunnels require the use of EZ-IPSec on the client XSR, placing the majority of the configuration effort on the central site XSR.

Client Mode

When the XSR connects to the central site tunnel server, the tunnel server assigns the client XSR an IP address, which can be chosen from an internal pool kept by the tunnel server. Hosts residing on the private LAN obtain IP addresses from the DHCP server running in the XSR.

Each session between a host on the private LAN and a server on the corporate network is *NAT-ed*. From the corporate perspective, the entire private LAN is represented as a single IP address. Since hosts on the private LAN are not visible from the corporate network, traffic must be initiated from

the hosts on the private LAN. The XSR's internal NAT operates only on Layer-4 protocols such as TCP and UDP. NAT also employs a set of modules - Application Level Gateway (ALG) - processing non-UDP/TCP protocols such as ICMP and H323.

Routing updates are unidirectional - the Central site advertises segments reachable in the corporate network, but the client XSR does not advertise the private LAN. After receiving a routing update, the client XSR can leverage a connection to the Internet for a VPN connection and access to public services and Web servers located on the Internet. This is called *split-tunneling*.

A secure tunnel to the Central site is established by means of ISAKMP Aggressive Mode with pre-shared keys or Main Mode using certificates. The assignment of IP addresses requires the support of Mode-Config on the tunnel server and the client XSR. Since Config Mode is not standardized, using it may affect interoperability with third-party devices.

Network Extension Mode (NEM)

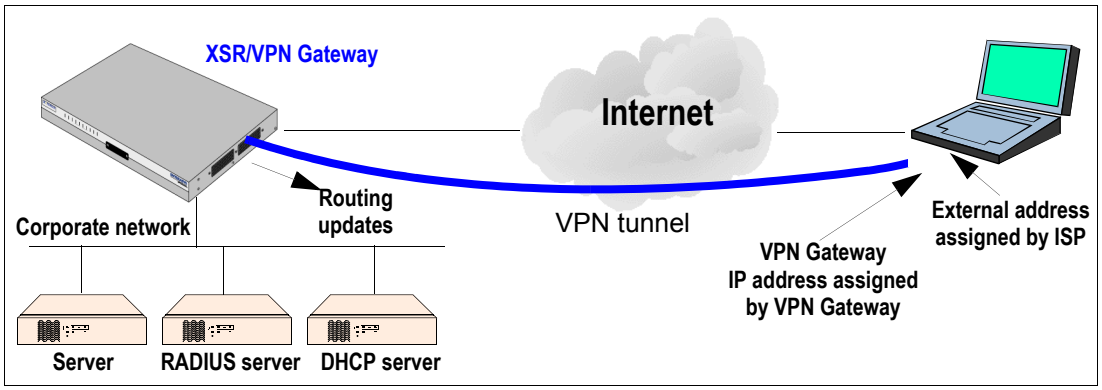
In the Network Extension scenario, as illustrated in Figure 14-6, the branch LAN is visible from the corporate segment since addressing used on that LAN augments addressing used on the corporation network. Hosts located on the branch LAN obtain IP addresses from the main DHCP server located on the corporate network. In this application the XSR must support the DHCP Relay protocol (RFC-3046) to extend hosts' DHCP requests for IP addresses. An obvious limitation of this configuration is that hosts cannot obtain IP addresses before a tunnel to the corporate network is created. A secure tunnel to the tunnel server is established by means of IETF ISAKMP Aggressive Mode transaction with pre-shared keys or Main Mode using certificates.

Remote Access Networks

In a Remote Access application, as shown in Figure 14-7, a client connects to the corporate network in the same way as a dial-in user does. First, the client connects to an ISP and is assigned an external IP address, which is used to route packets over the Internet.

Then, the remote client initiates a tunnel to the XSR and is assigned an internal IP address belonging to the corporate network. After connecting, the remote client runs as if directly linked to the corporate LAN.

Figure 14-7 VPN Remote Access Topology



Many protocols provide remote access functionality. Windows 95/98 supports remote access using PPTP with MPPE, Windows 2000 supports L2TP over IPSec.

Depending on the protocol, the remote access scenario may require user authentication as well as *machine* authentication. A user database may be located on the XSR itself or a RADIUS server

behind the XSR. After a tunnel has been built, the XSR may advertise routing information about the corporate network to the client.

Authentication can be performed in several ways depending on the protocol used. For PPTP, authentication is achieved by means of PPP-based methods such as MS-CHAP, EAP, and PAP. It should be noted that some of these methods are not secure because password and user IDs traverse the Internet in clear-text. In the case of PPTP, there is no machine-level authentication.

For L2TP over IPSec, before an L2TP connection can be established between a client and the XSR, an IPSec connection must be created. The IPSec connection can be authenticated with certificates or pre-shared keys. For scalability, certificates are recommended.

User authentication is PPP-based, but since the L2TP session is protected by IPSec, any form of PPP authentication is secure.

Using OSPF Over a VPN Network

OSPF on the XSR dynamically discovers networks and adjusts the routing table when network connections fail (refer to "Configuring OSPF with Fail Over (Redundancy)" on page 14-17). The VPN protocols provide secure packet transport over the public network through the use of cryptographic policies attached to XSR interfaces.

When OSPF and VPN protocols are both employed over a network, contradictions may arise. For example, OSPF may advertise that a particular network segment is reachable, but VPN policies may prohibit traffic destined for that segment.

To avoid this problem, you must use care when configuring both protocols. The following sections describe different VPN scenarios and how OSPF is used with them.

OSPF Commands

The same OSPF commands available for configuration in Fast/GigabitEthernet or Serial Interface mode are available in Interface VPN mode. They are:

- **`ip ospf authentication-key`**
- **`ip ospf cost`**
- **`ip ospf dead-interval`**
- **`ip ospf hello-interval`**
- **`ip ospf message-digest-key`**
- **`ip ospf priority`**
- **`ip ospf retransmit-interval`**
- **`ip ospf transmit-delay`**

Additionally, **`show ip ospf interface vpn`** is available in EXEC mode.

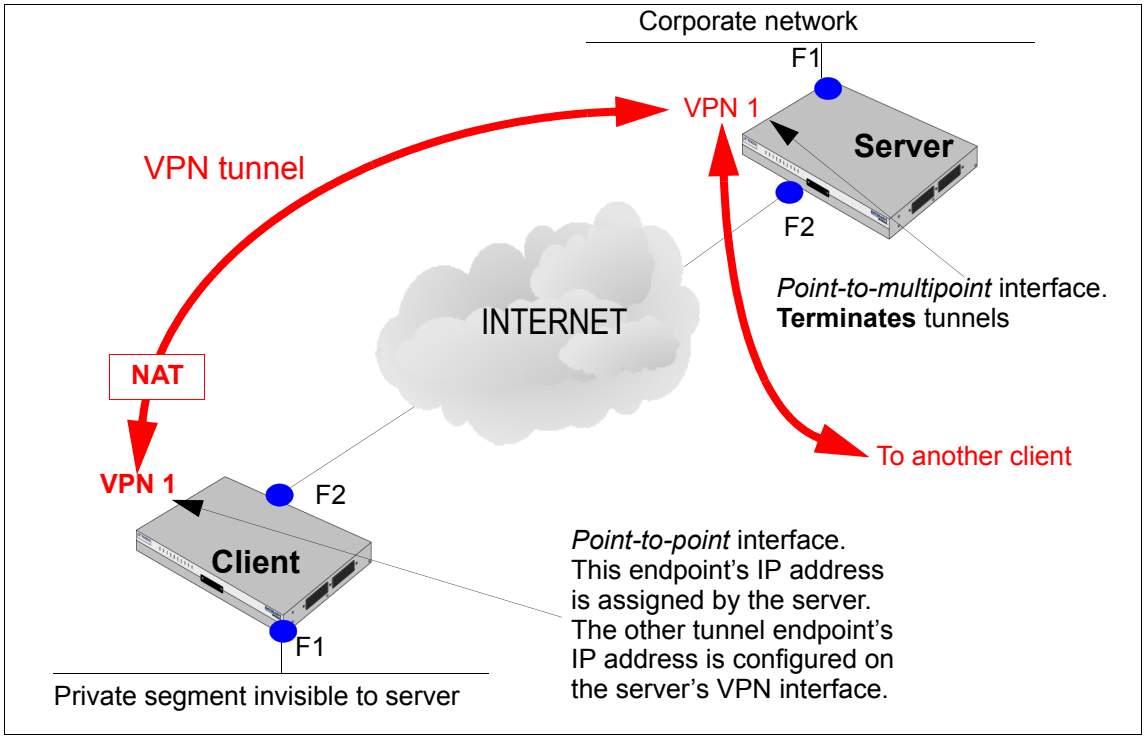
Configuring OSPF Over Site-to-Central Site in Client Mode

When the XSR is configured in a Client Mode, Site-to-Central Site application, it creates an asymmetric connection with one side acting as the server and the other as the client. The client *initiates* the tunnel upon node startup, requesting an IP address from the server.

From the client's point of view, the tunnel is a point-to-point connection; the VPN (virtual) interface associated with the tunnel must be a point-to-point interface. Each connected client is issued an IP address.

From the server's point of view, connected tunnels are point-to-multipoint links. The VPN interface serving as the server's tunnel endpoint must be a point-to-multipoint interface. Additionally, the server does not see segments behind the clients because in Client Mode, NAT is employed inside the tunnel and all traffic originating from trusted segments is NAT-ed with the IP address assigned by the server, as shown in Figure 14-8.

Figure 14-8 Site-to-Site Client Mode Topology



In this scenario, you may use OSPF to advertise the corporate network's reachability via an established tunnel.

Advertising these networks becomes extremely valuable when the client connects to more than one server. In that case, the client will have two VPN interfaces, expressed here as VPN 1 and VPN 2. Routes learned via OSPF will inform the IP routing engine which IP addresses are reachable via the VPN 1 interface and which are reachable via the VPN 2 interface. Based on the example shown in Figure 14-8, the following OSPF settings should be applied to the interfaces:

Server

- *Fast/GigabitEthernet 1* interface: This trusted side of the network on the XSR may consist of more than one IP segment. A network attached to Fast/GigabitEthernet 1 will be advertised in an OSPF area.
- *Fast/GigabitEthernet 2* interface: OSPF must be *disabled* here because this is the default external connection to the Internet. The server should not receive updates from the Internet nor pass along information about private segments to the Internet.
- *VPN 1* interface: OSPF is required here to establish adjacency with connecting clients. OSPF treats a set of connected clients as a point-to-multipoint network. Before swapping OSPF packets, the server must separately build adjacency with each connected client. If the server cannot establish OSPF adjacency with a client, it will not send OSPF updates to that client.

Client

- *Fast/GigabitEthernet 1* interface: This is private, non-routable segment, usually 192.168.1.0/24. OSPF must be disabled on F1. If OSPF is *enabled* on this interface it will be advertised to the server. The server's IP routing table will learn a route to this segment via the VPN interface connected to the client. But it is unreachable because NAT is enabled. Be aware that if two clients advertise the same private segment, e.g., 192.168.1.0/24, the server will learn two routes, which seem to be the same destination, but in fact are not.
- *Fast/GigabitEthernet 2* interface: OSPF should be *disabled* here for the same reason it is disabled on the server.
- *VPN 1* interface: OSPF must be *enabled* on this interface to receive updates from the server.

If other clients connecting to the VPN 1 interface on the server do not have OSPF coverage (i.e., Windows remote access clients), OSPF ignores them and continues exchanging information with those clients that support OSPF.

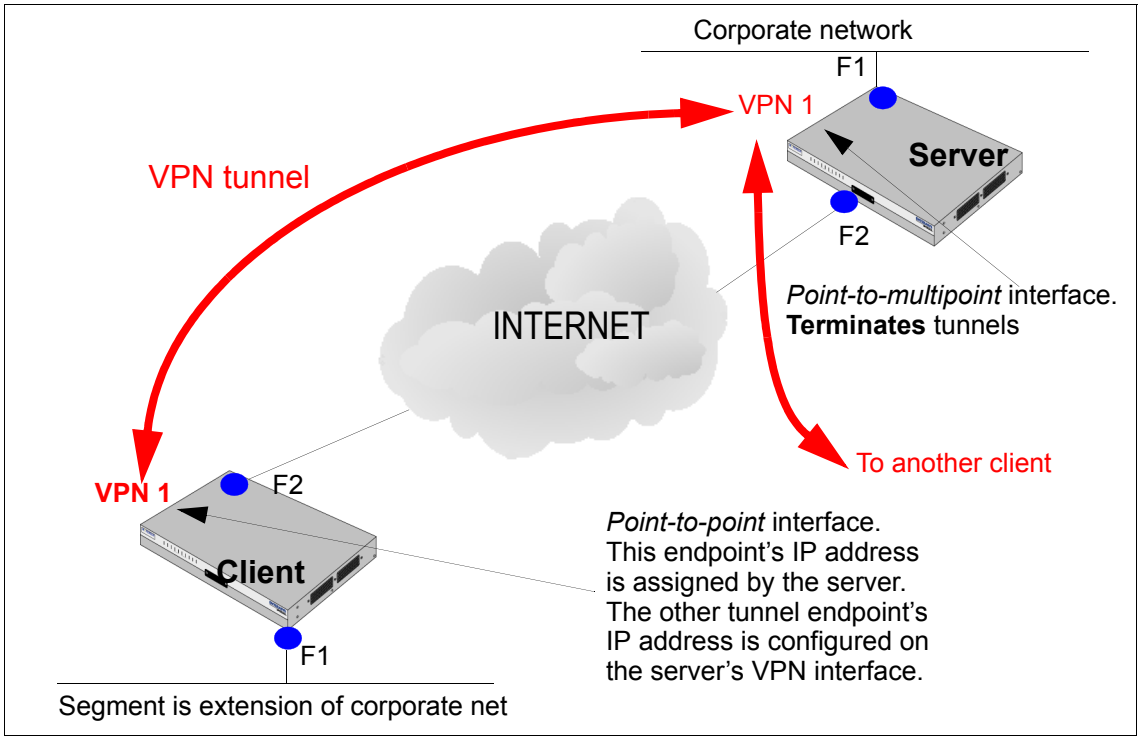
On the client, a tunnel associated with interface VPN 1 is created by means of the XSR's EZ-IPsec functionality. EZ-IPsec automatically inserts SPDs on Fast/GigabitEthernet interface 2 which specify that only traffic from and to the IP address assigned by the server should be encrypted. There is no conflict between SPDs and OSPF routing on this connection.

The commands to configure this scenario are illustrated on (page 14-36).

Configuring OSPF over Site-to-Central Site in Network Extension Mode

Compared to Client Mode, Network Extension Mode is more flexible at the cost of a more sophisticated configuration. As shown in Figure 14-9, NAT is not used on the VPN interface at the client site. The trusted network behind the client is a fully routable segment and may be reached from the corporate network.

Figure 14-9 Site-to-Site Network Mode Topology



The VPN interface on the server may terminate a mix of connections - some of which may be Client-type connections and others may be Network Extension connections.

The following OSPF settings should be applied in this scenario:

Server

Apply the same settings as in the Client Mode scenario. OSPF is enabled on Fast/GigabitEthernet 1 and VPN 1 interfaces and is disabled on Fast/GigabitEthernet 2.

Client

- As in the Client Mode model, OSPF is enabled on VPN 1 and disabled on Fast/GigabitEthernet 2.
- Additionally, OSPF is enabled on Fast/GigabitEthernet 1 because the route to network Fast/GigabitEthernet 1 should be learned at the central site's network.

The tunnel associated with interface VPN 1 on the client is created by EZ-IPsec, which automatically creates and attaches *two* sets of SPDs to interface Fast/GigabitEthernet 2. The first set specifies that traffic to and from the IP address assigned to the VPN interface should be encrypted. The second SPD specifies that traffic originating from and destined for the segment attached to Fast/GigabitEthernet 1 should be encrypted.

Network extension mode lets you add more segments attached to interface F1. If those segments are advertised using OSPF, routes to those segments will be known at the central site network. But, any traffic destined for those segments will be dropped because security policy described by crypto maps prohibits such traffic.

This situation may be addressed by extending crypto maps attached to both the client and the server. An example of such a network extension is illustrated in "XSR with VPN - Central Gateway" on page 14-36.

Configuring OSPF with Fail Over (Redundancy)

In this scenario, the client initiates two tunnels to two servers which are connected on their trusted sides. With alternate paths to the trusted network behind the servers (via the client's two tunnels), OSPF learns two paths of identical costs but uses the first learned path.

Should the tunnel serving that path become non-functional, OSPF recalculates the routes and uses the alternate path. The interval between link failure and the switch to the new route depends on the following OSPF parameters set on the VPN interfaces:

- *hello-interval* - This specifies how often hello packets are sent to the neighbor.
- *dead-interval* - This sets the peak interval that may elapse without receiving a hello packet from the neighbor before the link is declared non-operational.

Setting those parameters low will generate more traffic on the link but guarantees faster detection of link failure. As shown in Figure 14-10, OSPF is *enabled* on the following interfaces:

Server 1

Interfaces Fast/GigabitEthernet 1 and VPN 1

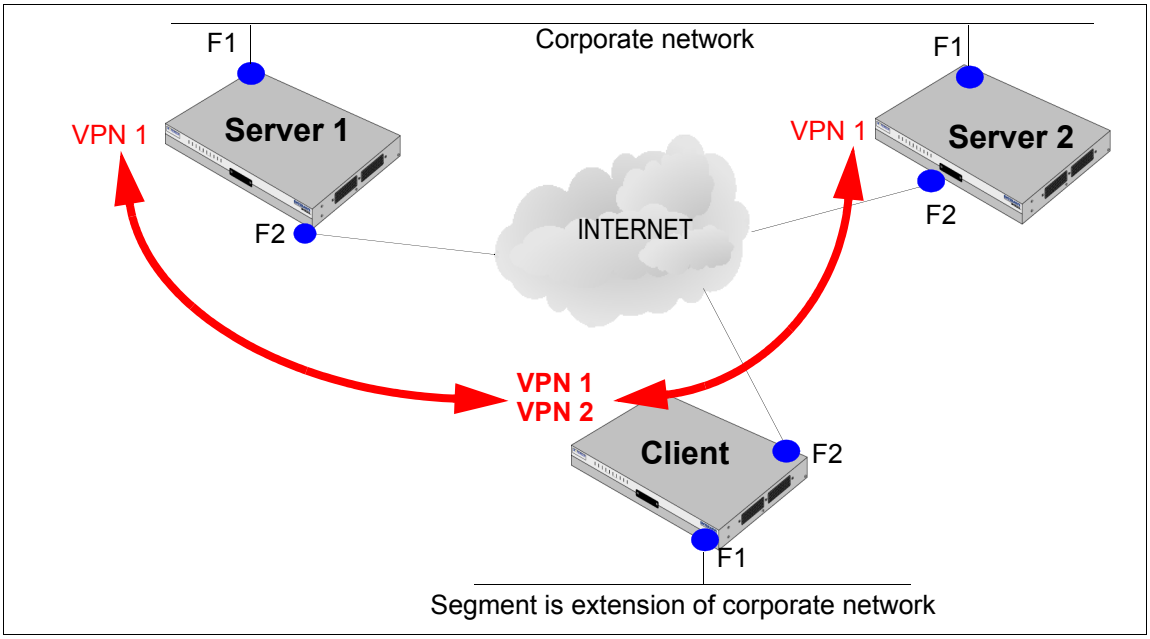
Server 2

Interfaces Fast/GigabitEthernet 1 and VPN 1

Client

Interfaces Fast/GigabitEthernet 1, VPN 1 and VPN 2.

Figure 14-10 OSPF Used with Failover



Limitations

Peer-to-Peer IPSec tunnels are configured without the VPN interface by applying crypto maps to *physical* interfaces. In this application, IPSec is treated as a side effect of data transmission through the interface. Since no virtual interface (VPN1, e.g.) is applied to the IPSec connection, a routing protocol like OSPF cannot be used.

As mentioned earlier, OSPF may advertise a network's reachability but IPSec policies may deny access to that network. As a remedy, you may extend the crypto maps attached to interfaces, but this requires prior knowledge of networks advertised by OSPF, which renders OSPF's dynamic network discovery useless. In this case, OSPF is used only for monitoring the links and providing alternate routes in case of link failure.

XSR VPN Features

The XSR supports the following VPN features:

- Site-to-Site (Peer-to-Peer) application
  - IPSec/IKE with pre-shared secrets
  - IPSec/IKE with certificates (PKI)
  - EZ-IPSec with PKI or pre-shared secrets:

    - Network Extension Mode (NEM)

- Client mode

- Remote Access application
  - Clients

    - Windows XP, 2000 (L2TP); NT 4.0, 98, 98 SE, ME, and CE. PPTP available on all clients
  - L2TP/IPSec protocols

    SCEP: Certificate and PKI environment

    - MS-CHAP v2, EAP user authentication:
      - Username/Password (local database and RADIUS)
      - SecurID (third-node plug-in)
      - Certificates (embedded/smart cards) – Microsoft only
  - PPTP protocol

    - MS-Chap V2, EAP user authentication
      - Local Database and RADIUS
      - SecurID (third-node plug-in)
      - Certificates (embedded/smart cards) – Microsoft only
- Encryption
  - Advanced Encryption Standard (AES), Triple Data Encryption Standard (3DES), Data Encryption Standard (DES)
  - 3DES acceleration available
- Data integrity
  - MD5 and SHA-1 algorithms
- Internet Protocol Security (IPSec)
  - Encapsulating Security Payload (ESP), Authentication Header (AH) and IPComp
  - Tunnel and Transport mode
  - Diffie-Hellman Groups 1, 2 and 5
  - *Mode Config* for IP address assignment
  - NAT Traversal via UDP encapsulation
- Public Key Infrastructure (PKI)
  - Microsoft Certificate Authority, Verisign (CA) support
  - Simple Certificate Enrollment Protocol (SCEP)
  - Microsoft Simple Certificate Enrollment Protocol (MSCEP)
  - Chained CA support
  - CRL checking (Hypertext Transfer Protocol [HTTP] and Lightweight Directory Access Protocol [LDAP])
- Network Address Translation (NAT) protocol
  - Static NAT
  - NAPT

- Authentication, Authorization, and Accounting (AAA) support including AAA per interface (for clients), AAA for PPP, and AAA debugging
- Dynamic Host Configuration Protocol (DHCP) support
  - DHCP Server
- OSPF over VPN
- DF Bit override on IPSec tunnels
- Copy TOS byte support (refer to"Configuring Quality of Service" on page 12-1 for a configuration examples)
- QoS on VPN (refer to"Configuring Quality of Service" on page 12-1 for more information)

VPN Configuration Overview

IPSec configuration entails the following basic steps. First, decide what type of VPN you want to configure from the following choices:

- *Site-to-Site* (Peer-to-Peer) using either pre-shared key or digital certificate (PKI) authentication
- *EZ-IPSec* using Client or Network Extension mode
- *Remote Access* using either L2TP/IPSec or PPTP

Consider that in Site-to-Site applications, the XSR can act as a gateway, or *terminator*, of tunnels and also as the client, or *initiator*, of tunnels. In Remote Access applications, the router can only act as a server.

Next, perform the following:

- Generate a *master encryption key* once on the XSR.
- Define ACLs to specify the type of traffic to be secured.
- Specify policies - IKE and IPSec *transform-sets* spell out authentication, encryption, data integrity, policy lifetime, and other values when negotiating Security Associations (SAs) with IPSec peers.
- Create a Security Policy Database (SPD) by configuring *crypto maps*, transform-sets, and ACLs.
- Configure authentication via *AAA* and/or *PKI.*
- Set up optional auxiliary functions including RADIUS, IP address assignment, and NAT.
- Configure a VPN interface, if required.

Master Encryption Key Generation

The XSR stores sensitive data such as user names, passwords, and certificates in **`Flash:`** directory files. Retaining this data in the clear would pose a security risk, so the XSR uses the master encryption key to encode it. The XSR is not supplied with a master encryption key at the factory - you must manually generate it before configuring VPN. To do so:

- Enter **crypto key master generate** in Global configuration mode.

  Caution: The master encryption key is stored in hardware, not Flash, and you cannot read the key - only overwrite the old key by writing a new one. To ensure router security, it is critical not to compromise the key. There are situations where you may want to keep the key, for example, to save the user database off-line in order to later download it to the XSR. In order to encrypt the user database, you need the same master key, indicating the key designation with the `master key specify` command. Be aware that if the XSR is inoperable and you press the Default button (on the XSR 1800 Series only), the master key is erased and you must generate a new one.

ACL Configuration Rules

Consider a few general rules when configuring ACLs on the XSR:

- Typically, two ACL sets are written, one to filter IPSec/IKE traffic (defined in crypto maps), and a *simple* set to filter non-IPSec traffic.
- When crypto maps and ACLs are configured on the same interface, the XSR gives precedence to the crypto map, which is always consulted before the ACL for both inbound and outbound traffic. If IPSec encrypts or decrypts packets by virtue of a crypto map configuration, then the ACL is ignored.
- ACLs entered independently are uni-directional but are used in a bi-directional fashion when later associated with a crypto map through the **`match address <acl #>`** command. For more information on the command, refer to the *CLI Reference Guide*.
- A total of 500 ACL entries are permitted by the XSR with 64 MBytes of RAM installed (99 ACL limit for IKE/IPSec).

Configuring ACLs

Three simple ACL examples illustrating various CLI options are detailed below. Other crypto map ACLs, defined in greater detail, are configured later in this chapter.

The first ACL example is fairly restrictive. It configures ACL *101* to permit IKE (UDP port 500), GRE, and TCP traffic on any internal host to pass to host 192.168.2.17 (denying all other traffic) and ACL *102* to permit the same type of traffic on that host to connect to any address (denying all other traffic).

The commands on FastEthernet port 2 set ACL 101 to filter *inbound* traffic, and ACL 102 to filter *outbound* traffic. Some commands are abbreviated.

```
XSR(config)#access-list 101 permit udp any host 192.168.2.17 eq 500
XSR(config)#access-list 101 permit gre any host 192.168.2.17
XSR(config)#access-list 101 permit tcp any host 192.168.2.17 established
XSR(config)#access-list 101 deny ip any any

XSR(config)#access-list 102 permit udp host 192.168.2.17 any eq 500
XSR(config)#access-list 102 permit gre host 192.168.2.17 any
XSR(config)#access-list 102 permit tcp host 192.168.2.17 any eq 80
XSR(config)#access-list 102 permit ip host 192.168.2.17 any
XSR(config)#access-list 102 deny ip any any

XSR(config)#interface FastEthernet2
XSR(config-if<F2>)#no shutdown
XSR(config-if<F2>)#ip access-group 101 in
XSR(config-if<F2>)#ip access-group 102 out
```

```
XSR(config-if<F2>)#ip address 141.154.196.87 255.255.255.192
```

If an XSR is configured as a VPN gateway, the external interface (FastEthernet 2, e.g.), can be made more restrictive by only allowing VPN protocols to pass through and barring all other traffic:

```
XSR(config)#access-list 100 permit esp any host 192.168.57.7
XSR(config)#access-list 100 permit ah any host 192.168.57.7
XSR(config)#access-list 100 per udp any eq 500 host 192.168.57.7 eq 500
XSR(config)#access-list 101 permit esp host 192.168.57.7 any
XSR(config)#access-list 101 permit ah host 192.168.57.7 any
XSR(config)#access-list 101 per udp host 192.168.57.7 eq 500 any eq 500
XSR(config-if<F2>)#interface FastEthernet2
XSR(config-if<F2>)#no shutdown
XSR(config-if<F2>)#ip access-group 100 in
XSR(config-if<F2>)#ip access-group 101 out
```

The following ACL example is fairly open, configuring the XSR as a VPN concentrator but allowing internal users access to the Internet. ACLs 101 and 102 are applied to the external interface - FastEthernet 2.

ACLs must be applied to the external interface of the XSR prior to the creation of a VPN configuration. These ACLs would only be applied to an XSR configured as a VPN concentrator that would also be used for Internet access.

```
XSR(config)#access-list 101 permit udp any any eq 500
XSR(config)#access-list 101 permit gre any any
XSR(config)#access-list 101 permit tcp any any established
XSR(config)#access-list 101 permit tcp any any eq 1723
XSR(config)#access-list 101 permit tcp any any eq 1701
XSR(config)#access-list 101 permit tcp any any eq 389
XSR(config)#access-list 101 pe ip host <public interface address> any
XSR(config)#access-list 101 deny ip any any

XSR(config)#access-list 102 permit udp any any eq 500
XSR(config)#access-list 102 permit gre any any
XSR(config)#access-list 102 permit tcp any any eq 80
XSR(config)#access-list 102 permit tcp any any eq 1723
XSR(config)#access-list 102 permit tcp any any eq 1701
XSR(config)#access-list 102 permit tcp any any eq 389
XSR(config)#access-list 102 deny ip any any

XSR(config)#interface fastethernet 2
XSR(config-if<F2>)#ip access-group 101 in
XSR(config-<F2>)#ip access-group 102 out
```

Selecting Policies: IKE/IPSec Transform-Sets

IKE proposals are configured by the **`crypto isakmp proposal`** command with the following parameters available:

- Pre-shared key or RSA signatures public key *authentication*
- Group 1, 2, and 5 Diffie-Hellman 768-, 1024-, and 1536-bit
- SA *lifetimes*

More than one IKE proposal can be specified on each node. When IKE negotiation begins, it seeks a common proposal on both peers with identical parameters. IKE policy is configured using the **crypto isakmp peer** command. Specified parameters are effective when a peer address/subnet matches the IP address of the peer. The wildcard 0.0.0.0 0.0.0.0 may be used to match any peer. Configurable IKE policy values are:

- IKE *peer address/subnet*
- IKE *proposal list*
- Client or server *Mode-config*
- Main or aggressive IKE *exchange mode* (outbound tunnels only)
- User-defined identification (with aggressive mode only)
- Enable or disabled *NAT* automatic options

Transform-sets used for IPSec are created by the **crypto ipsec transform-set** command. You can choose AH, ESP, or IP compression values as follows:

- MD5-HMAC or SHA-HMAC hashing algorithms
- 3DES, AES or DES *encryption*
- MD-5 or SHA-1 *hash* algorithms

Security Policy Considerations

Be aware of these considerations when configuring security policy:

- DES is a weaker form of encryption than 3DES and provides a lower level of security than the newer algorithm. We recommend 3DES.
- Selecting any Perfect Forward Secrecy (PFS) option will make each generated key used in data encryption independent of previous keys. If the key is compromised, the next key generated by Phase 2 exchange cannot be determined by knowing the value of the previous key. This comes at the cost of slightly lower performance.
- Two IPSec encapsulation modes are supported but the default, *tunnel mode*, is typically used with VPNs because it is more inclusive.
- It is useful to specify a *user ID* instead of an IP address when configuring an SA in aggressive mode (with pre-shared keys) for a peer whose IP address is dynamic. If you specify no ID, its IP address will be used by default. But, in that case, you will have to re-configure (with a new entry in the **aaa user** database) both ends of the tunnel every time the address changes. Use the **user-id** command instead.

Configuring Policy

The following example defines simple IKE Phase I, remote peer and IPSec transform-sets. Configure the IKE proposal *try1*:

```
XSR(config)#crypto isakmp proposal try1
XSR(config-isakmp)#authentication pre-share
XSR(config-isakmp)#encryption aes
XSR(config-isakmp)#hash md5
XSR(config-isakmp)#group 5
XSR(config-isakmp)#lifetime 40000
```

Configure IKE policy for the remote peer, assuming that two other IKE proposals (*try2* and *try3*) have been configured:

```
XSR(config)#crypto isakmp peer 192.168.57.33/32
XSR(config-isakmp-peer)#proposal try1 try2 try3
XSR(config-isakmp-peer)#config-mode gateway
XSR(config-isakmp-peer)#nat auto
```

Configure the IPSec transform set. You can specify both kilobyte and seconds SA lifetime values or just one. Some commands are abbreviated.

```
XSR(config)#crypto ipsec tr esp-3des-sha esp-3des esp-sha-hmac
XSR(cfg-crypto-tran)#set pfs group1
XSR(cfg-crypto-tran)#set sec lifetime kilobytes 500000
XSR(cfg-crypto-tran)#set sec lifetime seconds 3000
```

Creating Crypto Maps

A crypto map is a Security Policy Database (SPD) which filters and classifies packets as well as defines the policy applied to those packets. Filtering and classifying decides which traffic needs to be protected while policy affects the SA negotiation performed (via IKE) on behalf of that traffic.

IPSec crypto maps comprise the following:

- Traffic to be protected, configured with the **`match address`** sub-command.
- Which IPSec peers the protected traffic can be forwarded to, configured with the **`set peer`** sub-command. These are peers with which an SA can be negotiated.
- Which transform-sets are acceptable for protecting traffic, configure with the **`set transform-set`** sub-command.
- Which encapsulation type, *tunnel* or *transport*, should be used, configured with the **`mode`** sub-command.
- If SAs should be sought for each source/destination host pair, configured with the **`set security-association level per-host`** command. This command creates separate SAs per data stream. When it is off, each data stream passes through the same SA.

Configuring Crypto Maps

Crypto maps are sets of rules indexed by sequence number. For a given interface, certain traffic can be forwarded to one IPSec peer with specified security applied to it, and other traffic forwarded to the same or a different IPSec peer with different IPSec security applied.

The following sample crypto map *highflow* with rule #77 is correlated with a pre-configured transform-set and ACL *140*. It is attached to a remote gateway, specifying that SAs for traffic matching this rule be requested only with the specified gateway. Per-host SAs is disabled and the default *tunnel* mode is left unchanged.

```
XSR(config)#access-list 140 permit ip 192.168.57.0 0.0.0.255 192.168.58.0
0.0.0.255
XSR(config)#crypto map highflow 77
XSR(config-crypto-m)#set transform-set esp-3des-sha
XSR(config-crypto-m)#match address 40
XSR(config-crypto-m)#set peer 192.168.45.12
XSR(config-crypto-m)#no set security-association level per-host
```

Authentication, Authorization and Accounting Configuration

The XSR's AAA implementation handles all authentication, authorization and accounting of users (Remote Access) and peer gateways (Site-to-Site). The components include:

- Usernames and passwords for authentication
- Associated group name for authorization of network services
- IP addressing, including:
  - Virtual addresses from a local IP pool
  - DNS (primary and secondary) for remote access clients
  - WINS (primary and secondary) for remote access clients
- Encryption settings for PPTP remote access clients
- AAA per interface (for clients), for PPP, and debugging
- Configuration for standard RADIUS. In addition to all the necessary values for communicating securely with a RADIUS server, the XSR permits specifying a *backup* RADIUS server for authentication failover. Refer to the table below for supported attributes.

Table 14-2 XSR-Supported RADIUS Attributes

Authentication	Accounting	Vendor-Specific
User-Name (1)	Acct-Status-Type (40)	MSCHAP Response (1)
User-Password (2)	Acct-Input-Octets (42)	MSCHAP Error (2
NAS-IP-Address (4)	Acct-Output-Octets (43)	MSCHAP Domain (10)
Framed-IP-Address (8)	Acct-Session-Id (44)	MSCHAP Challenge (11)
Framed-IP-Netmask (9)	Acct-Session-Time (46)	MSCHAP MPPE Keys (12)
Framed-MTU (12)	Acct-Input-Packets (47)	MPPE Send Key (16)
Reply-Message (18)	Acct-Output-Packets (48)	MPPE Receive Key (17
Class (25)	Acct-Terminate-Cause (49)	MSCHAP2 Response (25)
State (24)		MSCHAP2 Success (26)
Vendor-Specific (26)		
NAS-Identifier (32)		
Login-LAT-Group (36		
NAS-Port-Type (61)		
EAP-Message (79		
Message-Authenticator (80)		

AAA Commands

The following XSR AAA commands useful for VPN configuration include:

- Configure users and groups with **`aaa user`** and **`aaa group`** commands as well as the following sub-commands:
  - **`policy`** specifies *SSH*, *Telnet*, *Firewall* or *VPN* service for users
  - **`dns-server`** and **`wins server`** configure the IP addresses of primary and secondary *DNS* and *WINS* servers to distribute to remote access users and connecting XSRs.
  - **`ip pool`** associates a globally defined *IP address pool* (set with **`ip local pool`**) with a user group. When a remote access user or XSR connects, an IP address is distributed from this pool. Be aware that if an AAA user is configured to use a *static* IP address which belongs to a local IP pool, you must exclude that address from the local pool.
  - **`pptp encrypt mppe`** configures Microsoft Point-to-Point Encryption on a PPTP link.
  - **`ip address`** and **`group`** set the IP address and usergroup assigned to the remote user.
- Configure RADIUS, local or PKI databases with the **`aaa method`** command as well as the following sub-commands:
  - **`acct-port`** sets the UDP port for accounting requests.
  - **`address`** specifies the RADIUS server address with either a host name or IP address.
  - **`attempts`** sets the total of consecutive, unanswered login attempts that must transpire before the RADIUS method's backup method is used.
  - **`auth-port`** specifies the UDP port for authentication requests.
  - **`enable`** activates the method.
  - **`group`** specifies the default usergroup.
  - **`hash enable`** initializes the hash algorithm used for RADIUS.
  - **`key`** sets the shared secret used between the XSR and RADIUS server.
  - **`retransmit`** specifies the number of RADIUS server retransmissions sent to a server before timing out.
  - **`timeout`** sets the interval the XSR waits for the RADIUS server to reply before retransmitting.
  - **`backup`** sets the name for the backup RADIUS method.
- Configure pre-shared keys with **`aaa user`** and **`password`**

Configuring AAA

Pre-shared keys used in a Peer-to-Peer tunnel are configured using the **`aaa user`** command:

- The Username is the IP address of a peer
- The Password is the *pre-shared key*

> **Caution:** We recommend that you do not create more AAA users than permitted by the 1.5 MByte system limit imposed on the **`user.dat`** file. Doing so may render the XSR unstable and require you to delete the file.

To specify a user and password, enter the following commands:

```
XSR(config)#aaa user <xxx.xxx.xxx.xxx>
```

```
XSR(aaa-user)#aaa password ThISisMYShaREDsecRET
```

The following sample configuration creates user *Jeremiah* in the *PromisedLand* usergroup, with DNS, WINS and MPPE encryption, and assigns IP local pool *remote_user*s for remote access:

```
XSR(config)#aaa group PromisedLand
XSR(aaa-group)#dns server primary 112.16.1.16
XSR(aaa-group)#dns server secondary 112.30.30.20
XSR(aaa-group)#wins server primary 112.16.1.16
XSR(aaa-group)#wins server secondary 112.16.1.13
XSR(aaa-group)#ip pool remote_users
XSR(aaa-group)#pptp encrypt mppe 128

XSR(config)#aaa user Jeremiah
XSR(aaa-user)#password amen
XSR(aaa-user)#group PromisedLand
```

Note: For generic AAA background information and configurations, refer to "AAA Services" on page 16-5.

PKI Configuration Options

The XSR's PKI implementation offers the following CLI commands to:

- Identify and configure attributes of Certificate Authorities using the **`crypto ca identity`** mode's available commands:
  - **`enrollment http-proxy`** specifies SCEP requests to be directed though an intermediate proxy server.
  - **`enrollment url -`** URL provided to access the CA (consult your CA administrator for this address). Any DNS names must be manually converted and entered as IP addresses. (Not *acme.com* but *192.168.1.1*).
  - **`enrollment retry count`** sets the number of retries for pended enrollment requests.
  - **`enrollment retry in period`** sets the interval between retries for pended enrollment requests.
  - **`crl frequency`** sets the interval between runs of the CRL maintenance task to update CRLs.
- Collect a CA certificate from a Certificate Authority: **`crypto ca authenticate`**. Note that you must verify the fingerprint of the CA against provided information as part of this operation to assure that the CA you access is the CA you expect.
- Enroll an IPSec client certificate for your XSR against an authenticated CA: **`crypto ca enroll`**.
- Immediately update CRL lists by entering **`crypto ca crl request`**.
- Display various aspects of the crypto configuration using the following **`show`** commands:
  - **`show crypto ca identity`** displays all configured CA identities
  - **`show crypto ca certificates`** displays all collected certificates (CA Identities and IPSec client certificates)
  - **`show crypto ca crls`** displays a list of applicable CRLs
- Remove individual certificates using the following commands:

  - **crypto ca certificate chain**
  - **no certificate** - The serial number can be found in: **show crypto ca certificates**
- Remove CA identities and all associated CA and IPSec client certificates by entering **no crypto ca identity <ca name>**.

Configuring PKI

The main steps to configure PKI are as follows:

- Obtain the CA name and URL
- Identify the CA, retrieve and authenticate the certificate
- Verify the root certificate was received
- Configure CA retrieval attributes and update CRLs
- Specify a host(s) for the CRL mechanism
- Enroll in an end-entity certificate
- Verify the end-entity certificate is valid
- Optional: change the enrollment retry period and count

For step-by-step instructions, refer to the following PKI Certificate example.

> **Note:** If you have multiple CAs in a chained environment, you need only identify each CA and obtain each CA certificate within the chain using the **crypto ca identity** and **crypto ca authenticate** commands, respectively, as illustrated in Step 2 on page 14-28.

PKI Certificate Enrollment Example

This PKI example illustrates authenticating to and enrolling with a Certificate Authority (CA) for an end-entity certificate for the IPSec gateway. Local IPSec uses end-entity certificates to establish SAs for IPSec connectivity. You must authenticate against all CAs which may have provided certificates to any of the remote systems that may be building IPSec links to the local system.

1. Begin by asking your CA administrator for your CA name and URL.

   The CA's URL defines its IP address, path and default port (80). You can resolve the CA server address manually by pinging its IP address.

2. Be sure that the XSR time setting is correct according to the UTC time zone so that it is synchronized with the CA's time. For example:

   ```
   XSR#clock timezone -5 0
   ```

3. Specify the enrollment URL, authenticate the CA and retrieve the root certificate. Check your CA Website to ensure the printed fingerprint matches the CA's fingerprint, which is retrieved from the CA itself, to verify the CA is legitimate. If bona fide, accept the certificate, if not, check that the certificate is deleted and not stored in the CA database. In some cases you may need to specify a particular CA identity name. Consult your administrator for more details.

   ```
   XSR(config)#crypto ca identity ldapca
   XSR(config-ca-identity)#enrollment url http://192.168.1.33/certsrv/mscep/
   mscep.dll/
   XSR(config-ca-identity)#exit
   XSR(config)#crypto ca authenticate ldapca
   ```

```
Certificate has the following attributes:
Fingerprint: D423E129 81904CE0 1E6D0FE0 A123A302
Do you accept this certificate? [yes/no] y
```

4. Display your CA certificates to verify all root and associated certificates are present. In the RA Mode example below, *ldapca* is the root CA of three certificates. Non-RA Mode CAs return one certificate only.

```
XSR(config)#show crypto ca certificates

CA Certificate - ldapca
 State:              CA-AUTHENTICATED
 Version:            V3
 Serial Number:      60836846550303873313949275026141128O9
 Issuer:           C=US, O=sml, CN=ldapca
 Valid From:         2002 Jun  4th, 12:40:46 GMT
 Valid To:           2004 Jun  4th, 12:48:15 GMT
 Subject:          C=US, O=sml, CN=ldapca
 Fingerprint:        D423E129 81904CE0 1E6D0FE0 A123A302
 Certificate Size:   1157 bytes

RA KeyEncipher Certificate - ldapca-rae
 State:              CA-AUTHENTICATED
 Version:            V3
 Serial Number:      4581289352733669300635З0
 Issuer:           C=US, O=sml, CN=ldapca
 Valid From:         2002 Jul 24th, 20:45:14 GMT
 Valid To:           2003 Jul 24th, 20:55:14 GMT
 Subject:          C=US, O=sml.com, CN=sml_requestor
 Fingerprint:        F1279D63 AFFC3D93 48E5F311 73A1D16F
 Certificate Size:   1695 bytes

RA Signature Certificate - ldapca-ras
 State:              CA-AUTHENTICATED
 Version:            V3
 Serial Number:      458128729515158954573993
 Issuer:           C=US, O=sml, CN=ldapca
 Valid From:         2002 Jul 24th, 20:45:13 GMT
 Valid To:           2003 Jul 24th, 20:55:13 GMT
 Subject:          C=US, O=sml.com, CN=sml_requestor
 Fingerprint:        91EB5A77 B5CA535A 077B65C5 65035615
 Certificate Size:   1695 bytes
```

5. Set the CRL retrieval rate and download the latest CRL (optional).

```
XSR(config)#crl frequency 12
XSR(config)#crypto ca crl request PKItestca1
```

6. Add a static host to store IP addresses for use by the CRL mechanism.

```
XSR(config)#ip host CRLrepository 223.125.57.88
```

7. *Optional*. To ensure Verisign CA support, provide the domain name that you specified when registering with Verisign by entering your company's domain name:

```
XSR(config)#ip domain acme.com
```

8. Enroll in an end-entity certificate from a CA for which you have previously authenticated; e.g., *ldapca*.

   The CLI script will prompt you to enter and re-enter a challenge password you create or is given to you by your CA administrator.

   Remember that if you create a password, save it so it can be used later in case you need to revoke the certificate. Respond *yes* to all questions. and jot down the certificate serial number for comparison purposes.

```
XSR(config)#crypto ca enroll ldapca
%
% Start certificate enrollment
Create a challenge password. You will need to verbally
provide this password to the CA Administrator in order to
revoke your certificate. For security reasons your password
will not be saved in the configuration.
Please make a note of it.
Password:****
Re-enter password:****
Request certificate from CA (y/n) ? y
You may experience a short delay while RSA keys are generated.
Once key generation is complete, the certificate request
will be sent to the Certificate Authority.
Use 'show crypto ca certificate' to show the fingerprint.
XSR(config)#<186>Aug 29 7:11:1 192.168.1.33 PKI: A certificate was successfully
received from the CA.
<186>Nov 13 21:03:20 63.81.64.58 AAA: Current device Time: 2003 Nov 13th, 21:03:20 GMT
<186>Nov 13 21:03:20 63.81.64.58 AAA: Certificate valid from: 2003 Nov 13th, 21:57:02 GMT
<186>Nov 13 21:03:20 63.81.64.58 AAA: Certificate valid to: 2004 Aug  5th, 16:16:08 GMT
```

9. Once the certificate is properly enrolled, issue the **show ca certificates** command to display the end-entity and other certificates. The first certificate shown, identified as being in ENTITY-ACTIVE state, is the *end-entity* certificate. Compare the Subject ID to the serial number earlier displayed by the enrollment script to verify its authenticity.

```
XSR#show crypto ca certificates

Certificate - issued by ldapca
 State:              ENTITY-ACTIVE
 Version:            V3
 Serial Number:      75289387826578118934757
 Issuer:           C=US, O=sml, CN=ldapca
 Valid From:       2003 Nov 13th, 22:16:00 GMT
 Valid To:         2004 Aug  5th, 16:16:08 GMT
 Subject:          unstructuredName=corp
 Fingerprint:        ABF37B67 7200CCDA 604CB10C D5AC7F49
 Certificate Size:   1590 bytes

CA Certificate - ldapca
 State:              CA-AUTHENTICATED
 Version:            V3
 Serial Number:      60836846550303873313949275026141128 09
```

```
 Issuer:          C=US, O=sml, CN=ldapca
 Valid From:        2002 Aug 5th, 12:40:46 GMT
 Valid To:          2004 Aug 5th, 12:48:15 GMT
 Subject:         C=US, O=sml, CN=ldapca
 Fingerprint:       D423E129 81904CE0 1E6D0FE0 A123A302
 Certificate Size:  1157 bytes

RA KeyEncipher Certificate - ldapca-rae
 State:             CA-AUTHENTICATED
 Version:           V3
 Serial Number:     4581289352733669300635 30
 Issuer:          C=US, O=sml, CN=ldapca
 Valid From:      2002 Sep 20th, 14:07:34 GMT
 Valid To:        2004 Aug  5th, 16:16:08 GMT
 Subject:         C=US, O=sml.com, CN=sml_requestor
 Fingerprint:       F1279D63 AFFC3D93 48E5F311 73A1D16F
 Certificate Size:  1695 bytes

RA Signature Certificate - ldapca-ras
 State:             CA-AUTHENTICATED
 Version:           V3
 Serial Number:     4581287295151589545739 93
 Issuer:          C=US, O=sml, CN=ldapca
 Valid From:        2002 Sep 20th, 20:45:13 GMT
 Valid To:          2004 Aug 5th, 20:55:13 GMT
 Subject:         C=US, O=sml.com, CN=sml_requestor
 Fingerprint:       91EB5A77 B5CA535A 077B65C5 65035615
 Certificate Size:  1695 bytes
```

10. *Optional*. Change the enrollment retry count and period to a value matching your CA administrator's needs.

    The following values handle "non-pending" mode at the CA when a certificate request could time out while waiting for a response. Six requests will be issued every 10 minutes.

```
XSR(config)#enrollment retry count 6
XSR(config)#enrollment retry period 10
```

Interface VPN Options

Some configurations require the construct of virtual interfaces that represent tunnels on the XSR. A virtual interface defined by the **`interface vpn`** command often represents IPSec tunnels configured automatically by EZ-IPSec. A VPN interface can also be configured as a *point-to-point* or a *point-to-multi-point* interface with the following conditions:

- The **`interface vpn [#] point-to-point`** command applies to Site-to-Site or EZ-IPSec tunnels *initiated* by the XSR
- The **`interface vpn [#] multi-point`** command applies to an XSR used as a gateway and tunnel *terminator*

VPN Interface Sub-Commands

The following sub-commands are available at VPN Interface mode:

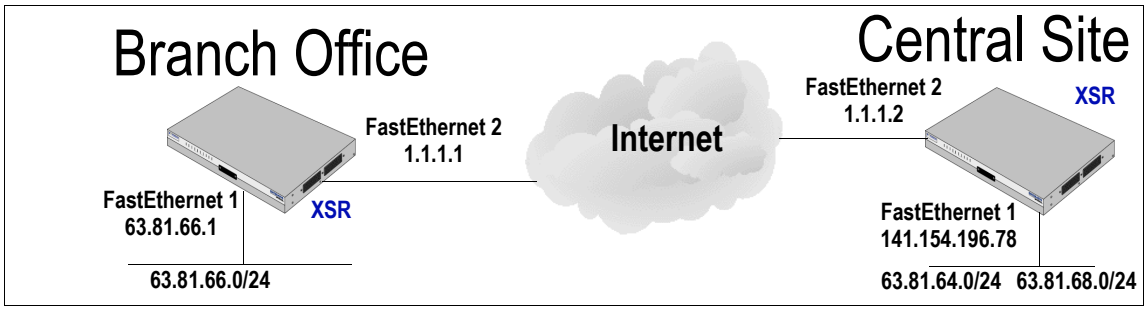
`ip firewall` + Set of commands to configure the firewall
`ip address-negotiated` + Sets the VPN interface's IP address to be negotiated
`ip address` + Specifies an IP address on the VPN interface
`ip multicast-redirect` + Redirects multicast to a unicast address
`ip nat` + Specifies NAT rules on the VPN interface
`ip rip` + Configures RIP routing on the VPN port
`ip unnumbered` + Enables IP processing on a serial port without assigning it an explicit IP address
`ip split-horizon` + Enables split horizon mechanism
`ip ospf` + Set of commands to configure OSPF routing
`tunnel` + Command and sub-commands configure a site-to-site VPN tunnel on a point-to-point interface
`set heartbeat` + Enables and configures tunnel connectivity monitoring
`set protocol (ipsec or gre)` + Selects a tunnel protocol
`set active` + Brings the tunnel up
`set user` + Designates the user name when initiating a tunnel and obtains credentials from the AAA subsystem
`set peer` + Sets the IP address of the peer

Configuring a Simple VPN Site-to-Site Application

The following main steps describe how to configure a simple Site-to-Site VPN between two XSRs, as illustrated in Figure 14-11:

- Encrypt *Branch*-site traffic on the 63.81.66.0/24 network to *Central* site networks (63.81.64.0/24, 63.81.68.0/24, 141.154.196.64/28)
- Set up IPSec/IKE policy with pre-shared keys
- Configure cryptographic algorithms (transform-sets) and IPSec mode
- Configure the VPN interface and crypto maps

Figure 14-11 Site-to-Site Example



1. Generate a master encryption key as described in "Master Encryption Key Generation" on page 14-20. This need only be done once on the router.
2. Begin Central Site configuration of all necessary physical and system requirements, including physical IP addresses, routing (default route and RIP or OSPF), and standard ACLs. This example offers numerous options.
3. Configure Access Lists 120, 130, and 140 to define the particular traffic to be protected by the tunnel. The ACLs allow a range of IP addresses on the VPN. In the context of VPN

configuration, permit means *protect* or *encrypt*, and deny indicates *don't encrypt* or allow *as is*.

```
XSR(config)#access-list 120 permit ip 141.154.196.64 0.0.0.63 63.81.66.0 0.0.0.255
XSR(config)#access-list 130 permit ip 63.81.64.0 0.0.0.255 63.81.66.0 0.0.0.255
XSR(config)#access-list 140 permit ip 63.81.68.0 0.0.0.255 63.81.66.0 0.0.0.255
```

4. Set up IKE Phase 1 protection by entering the following commands:

```
XSR(config)#crypto isakmp proposal Test
+ Designates ISAKMP proposal Test and acquires ISAKMP mode
XSR(config-isakmp)#authentication [pre-share | rsa]
+ Selects pre-shared key or certificates rsa-sig
XSR(config-isakmp)#encryption [aes | 3des | des]
+ Chooses encryption algorithm
XSR(config-isakmp)#hash [md5 | sha1]
+ Selects hash algorithm used by IKE
XSR(config-isakmp)#group [1 | 2 | 5]
+ Chooses Diffie-Hellman group
XSR(config-isakmp)#lifetime <seconds>
+ Sets IKE lifetime value
```

5. Configure IKE policy for the remote peer. Multiple IKE proposals can be configured on each peer participating in IPSec. When IKE negotiation begins, it tries to find a common proposal (policy) on both peers with a common proposal containing exactly the same encryption, hash, authentication, and Diffie-Hellman parameters (lifetime does not necessarily have to match).

```
XSR(config)#crypto isakmp peer 0.0.0.0 0.0.0.0
+ Configures the IKE peer IP address/subnet and acquires ISAKMP mode
XSR(config-isakmp-peer)#proposal Test
+ Specifies proposal lists test1 and test2
XSR(config-isakmp-peer)#exchange mode [main | aggressive]
+ Selects IKE main mode
XSR(config-isakmp-peer)#nat-traversal [auto | enabled | disabled]
+ Selects NAT traversal setting
```

6. Create a transform-set which adds the specified encryption/data integrity algorithms, 768-bit (Group 1) Diffie-Hellman, and your choice of an SA lifetime. You can specify an SA lifetime of seconds *and* kilobytes - whichever value runs out first will cause a rekey.

```
XSR(config)#crypto ipsec transform-set esp-3des-sha esp-3des esp-sha-hmac
+ Names transform-set with encryption and data integrity values
XSR(cfg-crypto-tran)#set pfs group1
+ Set PFS group number
XSR(cfg-crypto-tran)#set security-association lifetime [kilobytes | seconds]
+ Sets SA lifetime in either kilobytes or seconds
```

7. Configure three crypto map *Test* entries which correlate with specified transform-sets and ACLs 140, 130 and 120, attach the map to a remote peer, configure an independent SA for each traffic stream to a host, and select your choice of IPSec mode. Crypto map match statements render the associated ACLs bi-directional.

```
XSR(config)#crypto map Test 40
+ Adds crypto map Test, sequence #40
XSR(config-crypto-m)#set transform-set esp-3des-sha
+ Correlates map with the specified transform set
```

```
XSR(config-crypto-m)#match address 140
```
+ **Applies map to ACL 140 and renders the ACL bi-directional**

```
XSR(config-crypto-m)#set peer 1.1.1.2
```
+ **Attaches map to peer**

```
XSR(config-crypto-m)#mode [tunnel | transport]
```
+ **Selects IPSec mode for XSR-to-XSR (tunnel) or host to XSR (transport)**

```
XSR(config-crypto-m)#set security-association level per-host
```
+ **Sets a separate SA for every traffic flow**

```
XSR(config)#crypto map Test 20
```
+ **Adds crypto map *Test*, sequence #20**

```
XSR(config-crypto-m)#set transform-set esp-3des esp-sha-hmc
```
+ **Correlates map with the specified transform set**

```
XSR(config-crypto-m)#match address 120
```
+ **Applies map to ACL 120 and renders the ACL bi-directional**

```
XSR(config-crypto-m)#set peer 1.1.1.3
```
+ **Attaches map to peer**

```
XSR(config-crypto-m)#mode [tunnel | transport]
```
+ **Selects IPSec mode**

```
XSR(config-crypto-m)#set security-association level per-host
```
+ **Sets a separate SA for every traffic flow**

```
XSR(config)#crypto map Test 30
```
+ **Adds crypto map *Test*, sequence #30**

```
XSR(config-crypto-m)#set transform-set esp-des esp-sha-hmc
```
+ **Correlates map with the specified transform set**

```
XSR(config-crypto-m)#match address 130
```
+ **Applies map to ACL 130 and renders the ACL bi-directional**

```
XSR(config-crypto-m)#set peer 1.1.1.2
```
+ **Attaches map to peer**

```
XSR(config-crypto-m)#mode [tunnel | transport]
```
+ **Selects IPSec mode**

```
XSR(config-crypto-m)#set security-association level per-host
```
+ **Sets a separate SA for every traffic flow.** Configuring the XSR VPN interface is the last main task to perform to set up the VPN.

```
XSR(config)#interface fastethernet 2
```
+ **Adds FastEthernet port 2 and acquires Interface mode**

```
XSR(config-if<F2>)#crypto map Test
```
+ **Attaches Crypto Map to interface and acquires Crypto Map mode**

```
XSR(config-crypto-m)#description "external interface"
```
+ **Names the interface**

```
XSR(config-crypto-m)#ip address 141.154.196.78 255.255.255.192
```
+ **Adds IP address/subnet to interface**

```
XSR(config-crypto-m)#no shutdown
```
+ **Enables interface**

Consult the *XSR Getting Started Guide* for another site-to-site example.

Configuring the VPN Using EZ-IPSec

The XSR's VPN provides a simple, largely automatic, IPSec configuration option called EZ-IPSec which predefines a variety of IKE and IPSec *proposals* and *transforms*, combining those objects with dynamically-defined Security Policy database rules.

This suite of IPSec and IKE *policies*, sorted by cryptographic strength, is offered to the central gateway which selects one policy based on its local configuration. EZ-IPSec also relies upon the IKE Mode Configuration protocol to obtain an IP address from the central gateway.

EZ-IPSec is invoked using the **crypto ezipsec** command in Interface mode to create a set of standard IPSec policies, relieving you of the complex manual process. It enables *dynamic routing* over an IPSec tunnel:

- Via Client or Network Extension Mode
- Supporting RIPv2 and OSPF through the tunnel

The security policy automatically created by **crypto ezipsec** specifies *transform-sets* for IPSec ESP using 3DES and AES encryption with SHA-1 and MD5 integrity algorithms. Also, IPSec SA lifetimes are set to 100 MBytes and 3600 seconds - whichever value is reached first will cause a rekey.

EZ-IPSec configuration is comprised of two components:

- Enabling EZ-IPSec security policies and attaching to a network interface using **crypto ezipsec** configured on any interface other than FastEthernet (XSR 1800 Series)/ GigabitEthernet (XSR 3000 Series). Those ports are used when Network Extension Mode is used.
- Defining a virtual interface (VPN) in point-to-point mode which initiates a tunnel to a gateway XSR

EZ-IPSec Configuration

The commands below are used to configure a VPN interface on the XSR. The **set protocol** command is needed to select the following modes:

- *Client Mode.* The virtual interface (**interface vpn #**) is assigned an address using Mode Config and an IPSec security policy rule is inserted into the external interface's SPD securing traffic to and from that address. NATP is enabled on the VPN interface.
- *Network Extension Mode*. Same as client mode except NAPT is disabled on the VPN interface and two crypto map entries are added to the external interface SPD. One rule secures traffic to the virtual interface's assigned address and the other secures traffic to the trusted network interface which is assumed to be Fast/GigabitEthernet 1.

The commands below require *manual* configuration in conjunction with **crypto ezipsec**:

- **interface vpn [1 -255]**
- **ip address negotiated**
- **tunnel [Tunnel Name]**
- **set user [username | certificate]**
- **set peer [My Remote VPN Server Address]**
- **set protocol ipsec [client-mode | network-extension-mode]**

For example, configure the following Network Extension Mode tunnel:

```
XSR(config)#interface vpn 1 point-to-point
```
+ Sets VPN interface *1* to initiate a tunnel connection and acquires VPN interface mode. You must *always* set a Point-to-Point tunnel at the remote site and Point-to-Multipoint tunnel at the central site

```
XSR(config-int-vpn)#ip address negotiated
```
+ Asks for dynamic virtual IP address assignment of this VPN interface by its peer

```
XSR(config-int-vpn)#tunnel Corporate
```
+ Names the site-to-site tunnel *Corporate*

```
XSR(config-tms-tunnel)#set user My_Remote_site
```
+ Indicates a pre-share key is being used. You must add an EZ-IPSec tunnel using the password of this user in the AAA database

```
XSR(config-tms-tunnel)#set peer 200.10.20.30
```
+ **Specifies the IP address of the remote peer**

```
XSR(config-tms-tunnel)#set protocol ipsec network-extension-mode
```
+ **Selects IPSec to initiate a NEM tunnel connection**

> **Note:** Pre-shared key proposals are used if a user name is supplied with a tunnel. If no user name is supplied, EZ-IPSec verifies the XSR has one or more valid certificates and it uses RSA signature authentication.

Most of the parameters shown below have been automatically entered by EZ-IPSec. Be aware that they do not appear in the *running-config* file.

```
crypto isakmp peer 200.10.20.30/32
proposal ez-ike-3des-sha-psk ez-ike-3des-md5-psk
config-mode client
exchange-mode aggressive
nat-traversal automatic
crypto map ez-ipsec 100
match address 100
set peer 200.10.20.30
mode tunnel
set transform-set ez-esp-3des-sha-pfs ez-esp-3des-md5-pfs
set transform-set ez-esp-aes-sha-pfs ez-esp-aes-md5-pfs
set transform-set ez-esp-3des-sha-no-pfs ez-esp-3des-md5-no-pfs
set transform-set ez-esp-aes-sha-no-pfs ez-esp-aes-md5-no-pfs
crypto map ez-ipsec 101
match address 101
set peer 200.10.20.30
```

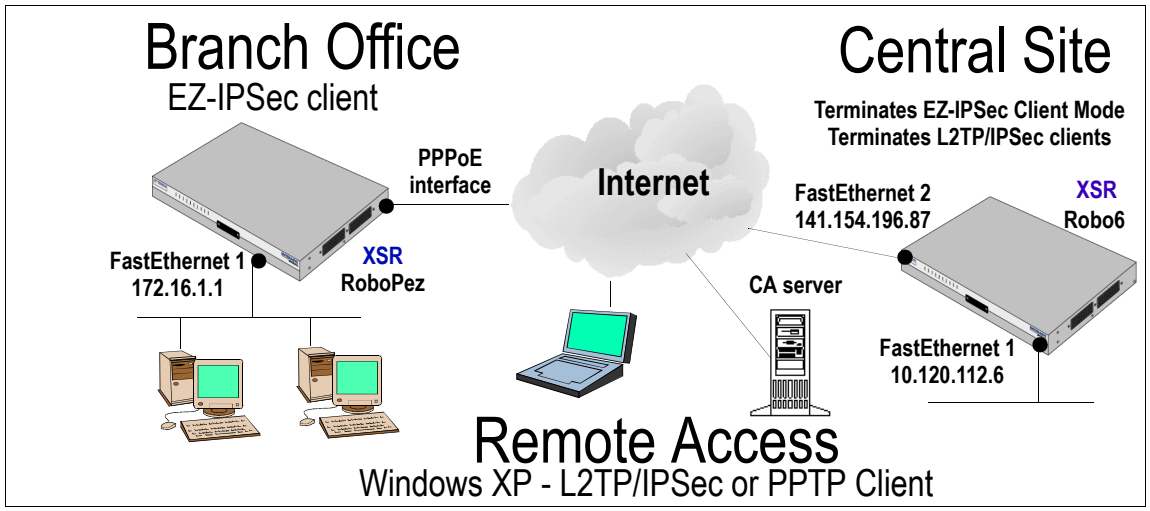
Configuration Examples

XSR with VPN - Central Gateway

In this scenario, as shown in Figure 14-12, a Central VPN gateway is set to perform the following:

- Terminate NEM and Client mode tunnels
- Terminate remote access L2TP/IPSec tunnels
- Terminate PPTP remote access tunnels
- OSPF routing with the next hop corporate router on the trusted VPN interface
- DF bit clear on the public VPN interface to handle large non-fragmentable IP frames
- OSPF routing over the multi-point VPN interface for other site-to-site tunnels
- Assign the first IP address of the pool to the multi-point VPN interface.

Figure 14-12 EZ-IPSec Client, XP Client and Gateway Topology



Begin by setting the XSR system time via SNTP. This configuration is critical for XSRs which use time-sensitive certificates.

```
XSR(config)#sntp-client server 10.120.84.3
XSR(config)#sntp-client poll-interval 60
```

Add ACLs to permit IP and UDP traffic:

```
XSR(config)#access-list 130 permit udp any any eq 500
XSR(config)#access-list 130 permit gre any any
XSR(config)#access-list 130 permit tcp any any est
XSR(config)#access-list 130 permit tcp any any eq 1723
XSR(config)#access-list 130 deny ip any any
```

Add ACLs for IP local pool/EZ-IPSec, Network Extension address and L2TP:

```
XSR(config)#access-list 110 permit ip any 10.120.70.0 0.0.0.255
XSR(config)#access-list 120 permit udp any any eq 1701
XSR(config)#access-list 140 permit ip any 172.16.1.0 0.0.0.255
XSR(config)#access-list 150 permit ip any 192.168.111.0 0.0.0.255
```

Define IKE Phase I security parameters with the following two policies:

```
XSR(config)#crypto isakmp proposal xp-soho
XSR(config-isakmp)#hash md5
XSR(config-isakmp)#lifetime 50000

XSR(config)#crypto isakmp proposal p2p
XSR(config-isakmp)#authentication pre-share
XSR(config-isakmp)#lifetime 50000
```

Configure IKE policy for the remote peer:

```
XSR(config)#crypto isakmp peer 0.0.0.0 0.0.0.0
XSR(config-isakmp-peer)#proposal xp-soho p2p
XSR(config-isakmp-peer)#config-mode gateway
XSR(config-isakmp-peer)#nat-traversal automatic
```

Configure the following four IPSec SAs:

```
XSR(config)#crypto ipsec transform-set esp-3des-md5 esp-3des esp-md5-hmac
XSR(cfg-crypto-tran)#no set security-association lifetime kilobytes
```

```
XSR(config)#crypto ipsec transform-set esp-3des-sha esp-3des esp-sha-hmac
XSR(cfg-crypto-tran)set security-association lifetime kilobytes 10000
```

Configure the following four crypto maps to match ACLs 150, 140, 120, and 110:

```
XSR(config)#crypto map test 50
XSR(config-crypto-m)#set transform-set esp-3des-sha
XSR(config-crypto-m)#match address 150

XSR(config)#crypto map test 40
XSR(config-crypto-m)#set transform-set esp-3des-sha
XSR(config-crypto-m)#match address 140

XSR(config)#crypto map test 20
XSR(config-crypto-m)#set transform-set esp-3des-md5
XSR(config-crypto-m)#match address 120
XSR(config-crypto-m)#mode transport
XSR(config-crypto-m)#set security-association level per-host

XSR(config)#crypto map test 10
XSR(config-crypto-m)#set transform-set esp-3des-sha
XSR(config-crypto-m)#match address 110
```

Configure and enable the FastEthernet 1 interface:

```
XSR(config)#interface FastEthernet1
XSR(config-if<F1>)#ip address 10.120.112.0/24
XSR(config-if<F1>)#no shutdown
```

Configure FastEthernet interface 2 with the attached crypto map *test*:

```
XSR(config)#interface FastEthernet2
XSR(config-if<F2>)#crypto map test
XSR(config-if<F2>)#ip address 141.154.196.87 255.255.255.192
XSR(config-if<F2>)#access-group 130 in
XSR(config-if<F2>)#access-group 130 out
XSR(config-if<F2>)#no shutdown
```

Configure the VPN virtual interface as a terminating tunnel server with IP multicast redirection back to the gateway, add an OSPF network with cost and disable the firewall:

```
XSR(config)#interface Vpn1 multi-point
XSR(config-int-vpn)#ip multicast-redirect tunnel-endpoint
XSR(config-int-vpn)#firewall disable
XSR(config-int-vpn)#ip address 10.120.70.1 255.255.255.0
XSR(config-int-vpn)#ip ospf priority 10
XSR(config-int-vpn)#ip ospf network nbma
```

Add a default route to the next hop Internet gateway:

```
XSR(config)#ip route 0.0.0.0 0.0.0.0 141.154.196.93
```

Define an IP pool for distribution of tunnel addresses to all client types:

```
XSR(config)#ip local pool test 10.120.70.0/24
```

Create hosts to resolve hostnames for the certificate servers for CRL retrieval:

```
XSR(config)#ip host parentca 141.154.196.89
XSR(config)#ip host childca2 141.154.196.81
XSR(config)#ip host childca1 141.154.196.83
```

Clear the DF bit globally:

```
XSR(config)#crypto ipsec df-bit clear
```

Enable the OSPF engine, VPN and FastEthernet 1 interfaces for routing:

```
XSR(config)#router ospf 1
XSR(config-router)#network 10.120.70.0 0.0.0.255 area 5.5.5.5
XSR(config-router)#network 10.120.112.0 0.0.0.255 area 5.5.5.5
```

Create a group for NEM and Client mode users:

```
XSR(config)#aaa group sohoclient
XSR(aaa-group)#dns server primary 10.120.112.220
XSR(aaa-group)#dns server secondary 0.0.0.0
XSR(aaa-group)#wins server primary 10.120.112.220
XSR(aaa-group)#wins server secondary 0.0.0.0
XSR(aaa-group)#ip pool test
XSR(aaa-group)#pptp encrypt mppe 128
XSR(aaa-group)#policy vpn
```

Define a group for remote access XP users including DNS and WINs servers, an IP pool, PPTP and L2TP values, and client VPN permission:

```
XSR(config)#aaa group XPusers
XSR(aaa-group)#dns server primary 10.120.112.220
XSR(aaa-group)#dns server secondary 0.0.0.0
XSR(aaa-group)#wins server primary 10.120.112.220
XSR(aaa-group)#wins server secondary 0.0.0.0
XSR(aaa-group)#ip pool test
XSR(aaa-group)#pptp encrypt mppe 128
XSR(aaa-group)#policy vpn
```

Configure the RADIUS AAA method to authenticate remote access users:

```
XSR(config)#aaa method radius msradius default
XSR(aaa-method-radius)#backup test
XSR(aaa-method-radius)#enable
XSR(aaa-method-radius)#group DEFAULT
XSR(aaa-method-radius)#address ip-address 10.120.112.179
XSR(aaa-method-radius)#key welcome
XSR(aaa-method-radius)#auth-port 1812
XSR(aaa-method-radius)#acct-port 1646
XSR(aaa-method-radius)#attempts 1
XSR(aaa-method-radius)#retransmit 1
XSR(aaa-method-radius)#timeout 5
XSR(aaa-method-radius)#qtimeout 0
```

Set branch office EZ-IPSec on the PPPoE, FastEthernet sub-interface 2.2, using certificates:

```
XSR(config)#interface FastEthernet 1
XSR(config-if<F1>)#ip address 172.16.1.1 255.255.255.0
XSR(config-if<F1>)#no shutdown

XSR(config)#interface FastEthernet 2
XSR(config-if<F2>)#no shutdown
XSR(config)#interface fastethernet 2.2
XSR(config-if)#crypto ezipsec
```

```
XSR(config-if)#encapsulation ppp
XSR(config-if)#ip address negotiated
XSR(config-if)#ip mtu 1492
XSR(config-if)#ip nat source assigned overload
XSR(config-if)#ppp pap sent-username pezhmon password pezhmon
```

Configure the Network Extension Mode, site-to-site IPSec tunnel to the central site XSR (*Robo6*).

```
XSR(config)#interface vpn 1 point-to-point
XSR(config-int-vpn)#ip address neg
XSR(config-int-vpn)#tunnel Pipe
XSR(config-tms-tunnel)#set user certificate
XSR(config-tms-tunnel)#set protocol ipsec network
XSR(config-tms-tunnel)#set active
XSR(config-tms-tunnel)#set peer 141.154.196.86
XSR(config-int-vpn)# ip ospf cost 110
XSR(config-int-vpn)#ip ospf priority 0
XSR(config-int-vpn)#ip ospf network nbma
XSR(config)#ip route 0.0.0.0 0.0.0.0 FastEthernet 2.2
```

Create hosts to resolve hostnames for the certificate servers for CRL retrieval:

```
XSR(config)#ip host parentca 141.154.196.89
XSR(config)#ip host childca2 141.154.196.81
XSR(config)#ip host childca1 141.154.196.83
```

Enable the OSPF engine, VPN (Central site pool) and FastEthernet 1 interfaces for routing:

```
XSR(config)#router ospf 1
XSR(config-router)#network 10.120.70.0 0.0.0.255 area 5.5.5.5
XSR(config-router)#network 172.16.1.0 0.0.0.255 area 5.5.5.5
```

Consult the *XSR Getting Started Guide* for another NEM example.

GRE Tunnel for OSPF

Tunnel A: XSR-3250 VPN GRE Site-to-Site Tunnel

The following is an example of a single GRE over IPSec tunnel between an XSR-3250 (Tunnel A) and an XSR-1805 (Tunnel B) using IKE shared secrets for authentication.

1. Begin by creating an IPSec ACL to permit GRE traffic and protect it with IPSec. This ACL will be used by a crypto map in Step 5.

   ```
   XSR(config)#access-list 190 permit gre any any
   ```

2. Configure the ISAKMP proposal *shared* that uses IKE *main mode*, hash algorithm *md5*, an IKE SA lifetime of *3000* seconds, *group 2* setting, *3des* encryption, and IKE *pre-shared keys* authentication. Main mode, group 2, and 3DES values are defaults and are not displayed in the configuration.

   ```
   XSR(config)#crypto isakmp proposal shared
   XSR(config-isakmp)#authentication pre-share
   XSR(config-isakmp)#hash md5
   XSR(config-isakmp)#lifetime 3000
   ```

3. Specify the IP address for a remote peer (*Tunnel B*) to have an IKE conversation with using the ISAKMP proposal *shared*:

   ```
   XSR(config)#crypto isakmp peer 63.81.64.200 255.255.255.255
   ```

```
XSR(config-isakmp-peer)#proposal shared
```

4. Configure a set of three IPSec quick mode security parameters that the XSR-3000 is willing to negotiate to within the IKE conversation:

```
XSR(config)#crypto ipsec transform-set aes-md5 esp-aes esp-md5-hmac
XSR(cfg-crypto-tran)#set security-association lifetime kilobytes 25000
XSR(cfg-crypto-tran)#set security-association lifetime seconds 7200

XSR(config)#crypto ipsec transform-set 3des-md5 esp-3des esp-md5-hmac
XSR(cfg-crypto-tran)#set security-association lifetime kilobytes 25000
XSR(cfg-crypto-tran)#set security-association lifetime seconds 7200

XSR(cfg-crypto-tran)#crypto ipsec transform-set 3des-sha esp-3des esp-sha-hmac
XSR(cfg-crypto-tran)#set security-association lifetime kilobytes 25000
XSR(cfg-crypto-tran)#set security-association lifetime seconds 7200
```

5. Create crypto map *gre* allowing IPSec transport mode traffic matching the GRE ACL created above. The crypto map also allows the use of any of the three IPSec security parameters (*aes-md5, 3des-md5, 3des-sha*) created above. Be aware that the *peer* address is set to the public Internet address terminating the GRE tunnel.

```
XSR(config)#crypto map gre 190
XSR(config-crypto-m)#set transform-set aes-md5 3des-md5 3des-sha
XSR(config-crypto-m)#match address 190
XSR(config-crypto-m)#set peer 63.81.64.200
XSR(config-crypto-m)#mode transport
XSR(config-crypto-m)#set security-association level per-host
```

6. Add GigabitEthernet interface 1 as the *trusted* or *private* VPN interface - it is connected to the corporate network. Enable OSPF on this interface to join the corporate OSPF routing fabric.

```
XSR(config)#interface GigabitEthernet 1
XSR(config-if<G1>)#ip address 10.120.84.21 255.255.255.0
XSR(config-if<G1>)#ip ospf dead-interval 4
XSR(config-if<G1>)#ip ospf hello-interval 1
XSR(config-if<G1>)#no shutdown
```

7. Add GigabitEthernet interface 2 as the *external* or *public* VPN interface - it is directly connected to the Internet. Attach crypto map *gre* to this interface to allow IKE and IPSec traffic processing.

```
XSR(config)#interface GigabitEthernet 2
XSR(config-if<G2>)#crypto map gre
XSR(config-if<G2>)#ip address 63.81.64.100 255.255.255.0
XSR(config-if<G2>)#no shutdown
```

8. Add a VPN point-to-point GRE interface, enable *XSR1800 to* initiate an outbound tunnel (**`set active`** command), set the IP address of the remote VPN gateway (*63.81.64.200*), and redirect all multicast packets to a unicast address:

```
XSR(config)#interface vpn1 point-to-point
XSR(config-int-vpn)#ip multicast-redirect 192.168.1.1
XSR(config-int-vpn)#tunnel "XSR1800"
XSR(config-tms-tunnel)#set protocol gre
XSR(config-tms-tunnel)#set active
XSR(config-tms-tunnel)#set peer 63.81.64.200
XSR(config-tms-tunnel)#ip address 192.168.1.2 255.255.255.0
```

```
XSR(config-tms-tunnel)#ip ospf dead-interval 4
XSR(config-tms-tunnel)#ip ospf hello-interval 1
XSR(config-tms-tunnel)#ip ospf cost 100
```

9. Configure a default static route to the next hop Internet router:

```
XSR(config)#ip route 0.0.0.0 0.0.0.0 63.81.64.1
```

10. Enable OSPF on the trusted and VPN interfaces:

```
XSR(config)#router ospf 1
XSR(config-router)#network 10.120.84.0 0.0.0.255 area 0.0.0.0
XSR(config-router)#network 192.168.1.0 0.0.0.255 area 0.0.0.0
```

Tunnel B: XSR-1805 VPN GRE Site-to-Site Tunnel

This configuration shows an example of a single GRE over IPSec tunnel between an XSR-3250 and an XSR-1805 using IKE shared secrets for authentication.

1. Repeat Steps 1 and 2 as described in Tunnel A configuration.
2. Specify the IP address for any remote peer to have an IKE conversation with using the ISAKMP proposal *shared*:

```
XSR(config)#crypto isakmp peer 0.0.0.0 0.0.0.0
XSR(config-isakmp-peer)#proposal shared
```

3. Specify the same set of IPSec security parameters as in Step 4.
4. Create crypto map *gre* allowing IPSec transport mode traffic matching the GRE ACL created above. The crypto map also allows the use of any of the three IPSec security parameters (*aes-md5, 3des-md5, 3des-sha*) created above. Be aware that the *peer* address is set to the public Internet address terminating the GRE tunnel.

```
XSR(config)#crypto map gre 191
XSR(config-crypto-m)#set transform-set aes-md5 3des-md5 3des-sha
XSR(config-crypto-m)#match address 190
XSR(config-crypto-m)#set peer 63.81.64.101
XSR(config-crypto-m)#mode transport
XSR(config-crypto-m)#set security-association level per-host
!
XSR(config)#crypto map gre 190
XSR(config-crypto-m)#set transform-set aes-md5 3des-md5 3des-sha
XSR(config-crypto-m)#match address 190
XSR(config-crypto-m)#set peer 63.81.64.100
XSR(config-crypto-m)#mode transport
XSR(config-crypto-m)#set security-association level per-host
```

5. Add FastEthernet interface 1 as the *trusted* or *private* VPN interface - it is connected to the remote network.

```
XSR(config)#interface fastethernet 1
XSR(config-if<F1>)#ip address 172.16.84.1 255.255.255.0
XSR(config-if<F1>)#ip firewall disable
XSR(config-if<F1>)#no shutdown
```

6. Add FastEthernet interface 2 as the *external* or *public* VPN interface - it is directly connected to the Internet. Attach crypto map *gre* to this interface to allow IKE and IPSec traffic processing.

```
XSR(config)#interface fastethernet 2
XSR(config-if<F2>)#crypto map gre
```

```
XSR(config-if<F2>)#ip address 63.81.64.200 255.255.255.0
XSR(config-if<F2>)#no shutdown
```

7. Add a VPN point-to-point GRE interface with a heartbeat of nine seconds, enable *XSR3250A to* initiate an outbound tunnel (**set active** command), set the IP address of the remote VPN gateway (*63.81.64.100*), and redirect all multicast packets to a unicast address:

```
XSR(config)#interface vpn1 point-to-point
XSR(config-int-vpn)#ip multicast-redirect 192.168.1.2
XSR(config-int-vpn)#tunnel "XSR3000A"
XSR(config-tms-tunnel)#set protocol gre
XSR(config-tms-tunnel)#set active
XSR(config-tms-tunnel)#set peer 63.81.64.100
XSR(config-tms-tunnel)#set heartbeat 3 3
XSR(config-tms-tunnel)#ip address 192.168.1.1 255.255.255.0
XSR(config-tms-tunnel)#ip ospf dead-interval 4
XSR(config-tms-tunnel)#ip ospf hello-interval 1
XSR(config-tms-tunnel)#ip ospf cost 100
```

8. Configure a default static route to the next hop Internet router:

```
XSR(config)#ip route 0.0.0.0 0.0.0.0 63.81.64.1
```

9. Enable OSPF on the trusted and VPN interfaces:

```
XSR(config)#router ospf 1
XSR(config-router)#network 172.16.84.0 0.0.0.255 area 0.0.0.0
XSR(config-router)#network 192.168.1.0 0.0.0.255 area 0.0.0.0
```

XSR/Cisco Site-to-Site Example

The following Site-to-Site configuration connects a Cisco 2600 router with internal/external IP addresses of 192.168.3.5/192.168.2.5 to a XSR with internal/external IP addresses of 192.168.1.2/192.168.2.2. The commands are displayed as they would appear when displayed in the configuration file.

Cisco Configuration

```
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption

hostname Cisco2600

enable secret 5 $1$9ljt$kg86F7Y1vsa2Np0Zj5wDf1
enable password welcome

ip subnet-zero

ip host spatel 192.168.1.1

crypto isakmp policy 1
hash md5
authentication pre-share
group 2
lifetime 1200

crypto isakmp policy 20
hash md5
authentication pre-share
lifetime 1200
crypto isakmp key welcome address 192.168.2.2

crypto ipsec security-association lifetime seconds 1800

crypto ipsec transform-set esp-des-md5 esp-des esp-md5-hmac

crypto map regular 1 ipsec-isakmp
set peer 192.168.2.2
set security-association lifetime kilobytes 10000
set security-association lifetime seconds 7200
set transform-set esp-des-md5
set pfs group2
match address 110

fax interface-type fax-mail
mta receive maximum-recipients 0
```

```
interface FastEthernet0/0
ip address 192.168.3.5 255.255.255.0
speed auto
half-duplex
no cdp enable

interface FastEthernet0/1
ip address 192.168.2.5 255.255.255.0
duplex auto
speed auto
no cdp enable
crypto map regular

ip classless
ip route 0.0.0.0 0.0.0.0 192.168.2.1
ip route 192.168.1.0 255.255.255.0 192.168.2.2
ip http server
ip pim bidir-enable

access-list 110 permit ip 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255
dialer-list 1 protocol ip permit
dialer-list 1 protocol ipx permit

snmp-server group testgroup v3 auth
snmp-server community public RO
call rsvp-sync

mgcp profile default

dial-peer cor custom

line con 0
exec-timeout 0 0
line aux 0
line vty 0 4
password welcome
login
```

XSR Configuration

```
XSR(config)#access-list 120 permit ip 192.168.3.0 0.0.0.255 192.168.1.0 0.0.0.255

XSR(config)#crypto isakmp proposal test
XSR(config-isakmp)#authentication pre-share
XSR(config-isakmp)#encryption des
XSR(config-isakmp)#hash md5

XSR(config)#crypto isakmp peer 0.0.0.0 0.0.0.0
XSR(config-isakmp-peer)#proposal test
```

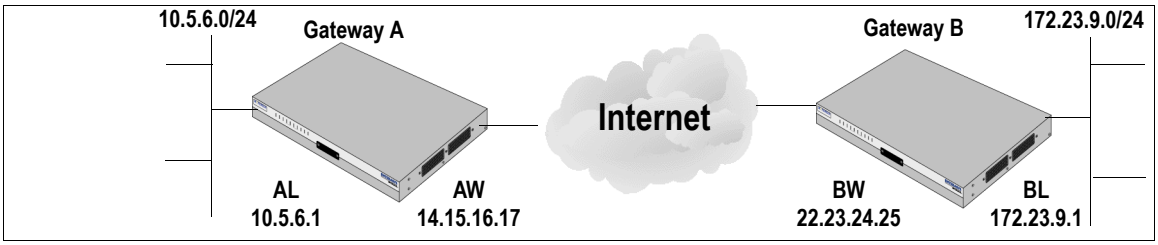
```
XSR(config)#crypto ipsec transform-set esp-des-md5 esp-des esp-md5-hmac
XSR(cfg-crypto-tran)#set pfs group2
XSR(cfg-crypto-tran)#no set security-association life kilo
XSR(cfg-crypto-tran)#set security-association life secon 700

XSR(config)#crypto map test 20
XSR(config-crypto-m)#set transform-set esp-des-md5
XSR(config-crypto-m)#match address 120
XSR(config-crypto-m)#set peer 192.168.2.5
XSR(config-crypto-m)#mode tunnel

XSR(config)#interface fastethernet 1
XSR(config-if<F1>)#no shutdown
XSR(config-if<F1>)#ip address 192.168.1.2 255.255.255.0

XSR(config)#interface fastethernet 2
XSR(config-if<F2>)#crypto map test
XSR(config-if<F2>)#no shutdown
XSR(config-if<F2>)#ip address 192.168.2.2 255.255.255.0

XSR(config)#ip route 192.168.3.0 255.255.255.0 192.168.2.5
XSR(config)#ip route 0.0.0.0 0.0.0.0 192.168.2.1

XSR(config)#snmp-server disable
```

Interoperability Profile for the XSR

Scenario 1: Gateway-to-Gateway with Pre-Shared Secrets

This section describes how to configure the XSR according to the VPN Consortium's interoperability scenarios (http://www.vpnc.org/). The following is a typical gateway-to-gateway VPN that uses a pre-shared secret for authentication, as illustrated in Figure 14-13.

Figure 14-13 Gateway-to Gateway with Pre-Shared Secrets Topology



Gateway A connects the internal LAN 10.5.6.0/24 to the Internet. Gateway A's LAN interface has the address 10.5.6.1, and its WAN (Internet) interface has the address 14.15.16.17.

Gateway B connects the internal LAN 172.23.9.0/24 to the Internet. Gateway B's WAN (Internet) interface has the address 22.23.24.25. Gateway B's LAN interface address, 172.23.9.1, can be used for testing IPsec but is not needed for configuring Gateway A.

The IKE Phase 1 parameters used in Scenario 1 are:

- Main mode
- Triple DES
- SHA-1
- MODP group 2 (1024 bits)
- Pre-shared secret of “hr5xb84l6aa9r6”
- SA lifetime of 28800 seconds (eight hours) with no Kbytes rekeying

The IKE Phase 2 parameters used in Scenario 1 are:

- Triple DES
- SHA-1
- ESP tunnel mode
- MODP group 2 (1024 bits)
- Perfect forward secrecy for rekeying
- SA lifetime of 3600 seconds (one hour) with no Kbytes rekeying
- Selectors for all IP protocols, all ports, between 10.5.6.0/24 and 172.23.9.0/24, using IPv4 subnets

This configuration assumes you have already set up the XSR for basic operations (refer to the *XSR Getting Started Guide)*. Also, you should have generated a master key (see the *XSR User Guide)*. To set up Gateway A for this scenario, perform the following steps on the CLI:

1. Configure the Gateway A internal LAN network (AL):
```
XSR(config)#interface FastEthernet1
XSR(config-if<F1>)#no shutdown
XSR(config-if<F1>)#ip address 10.5.6.1 255.255.255.0
```
2. Configure the Gateway A external LAN network (AW):
```
XSR(config)#interface FastEthernet2
XSR(config-if<F1>)#no shutdown
XSR(config-if<F1>)#ip address 14.15.16.17 255.255.255.0
```
3. Configure a simple, wide-open access list to permit all traffic from the source to the destination network:
```
XSR(config)#access-list 101 permit ip 10.5.6.0 0.0.0.255 172.23.9.0 0.0.0.255
```
4. Configure a default route:
```
XSR(config)#ip route 0.0.0.0 0.0.0.0 14.15.16.1
```
5. Configure IKE Phase 1 policy:
```
XSR(config)#crypto isakmp proposal Safe
XSR(config-isakmp)#authentication pre-share
XSR(config-isakmp)#encryption 3des
XSR(config-isakmp)#hash sha
XSR(config-isakmp)#group 2
XSR(config-isakmp)#lifetime 28800
```
6. Configure IKE policy *Safe* for the Gateway B remote peer. Optionally, multiple IKE proposals can be configured on each peer participating in IPSec.
```
XSR(config)#crypto isakmp peer 22.23.24.25 255.255.255.255
XSR(config-isakmp-peer)#proposal Safe
```

```
XSR(config-isakmp-peer)#config-mode gateway
XSR(config-isakmp-peer)#exchange-mode main
```

7. Configure IKE Phase 2 settings by creating the transform-set *Secure*:

```
XSR(config)#crypto ipsec transform-set Secure esp-3des esp-sha1-hmac
XSR(cfg-crypto-tran)#set pfs group2
XSR(cfg-crypto-tran)#set security-association lifetime seconds 3600
```

8. Configure the crypto map *Highflow* which correlates with transform-set *Secure* and access list 101, and attach the map to the remote peer.

```
XSR(config)#crypto map Highflow 1
XSR(config-crypto-m)#set transform-set Secure
XSR(config-crypto-m)#match address 101
XSR(config-crypto-m)#set peer 22.23.24.25
```

9. Attach the crypto map *Highflow* to the Gateway A external interface (AW):

```
XSR(config)#interface FastEthernet2
XSR(config-if<F2>)#crypto map Highflow
XSR(config-if<F2>)#no shutdown
```

10. Configure the pre-shared key. The username is the IP address of the peer and the password is the pre-shared key.

```
XSR(config)#aaa user 22.23.24.25
XSR(aaa-user)#password hr5xb84l6aa9r6
```

11. Test the connection by pinging a PC on the 172.23.9.0 network from the 10.5.6.0 network. Alternately, pinging the PC from Gateway A, if successful, will produce the output shown below. Be aware that for a ping to traverse the tunnel, you must configure an ACL with the host source and host destination IP addresses.

```
XSR#ping 172.23.9.5 10.5.6.1
Type escape sequence to abort
Reply from 172.23.9.5: 20ms
Reply from 172.23.9.5: 10ms
Reply from 172.23.9.5: 10ms
Reply from 172.23.9.5: 10ms
Reply from 172.23.9.5: 10ms
Packets: Sent = 5, Received = 5, Lost = 0
```

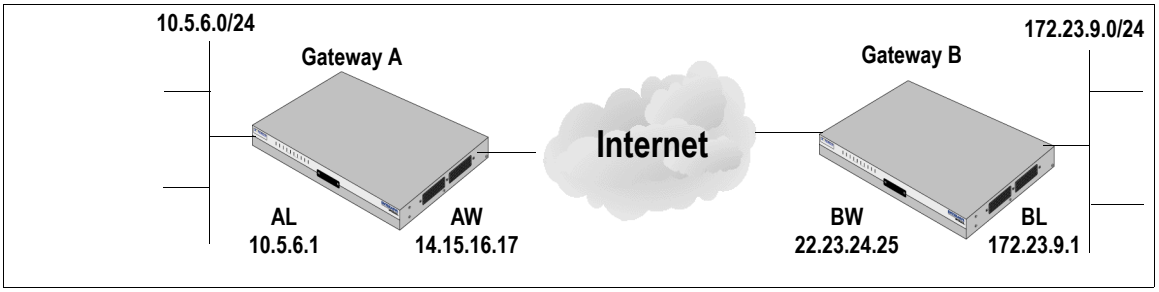
You can also issue the following **show** commands to examine Phase 1 and Phase 2 settings, respectively. When the tunnel is up, the commands will display the following output:

```
XSR#show crypto isakmp sa
Connection-ID  State     Source        Destination     Lifetime
------------   ----------------       -----------     -------
4561             QM_IDLE 14.15.16.17  22.23.24.25     28000

XSR#show crypto ipsec sa
10.5.6.0/24, ANY, 0 ==> 172.23.9.0/24, ANY, 0 : 92 packets
ESP: SPI=190d1f5f, Transform=3DES/HMAC-SHA, Life=3600S/0KB

172.23.9.0/24, ANY, 0 ==> 10.5.6.0/24, ANY, 0 : 98 packets
ESP: SPI=340d455a, Transform=3DES/HMAC-SHA, Life=3600S/0KB
```

Scenario 2: Gateway-to-Gateway with Certificates

The following is a typical gateway-to-gateway VPN that uses certificates for authentication, as illustrated in Figure 14-14.

Figure 14-14 Gateway-to Gateway with Certificates Topology



Gateway A connects the internal LAN 10.5.6.0/24 to the Internet. Gateway A's LAN interface has the address 10.5.6.1, and its WAN (Internet) interface has the address 14.15.16.17.

Gateway B connects the internal LAN 172.23.9.0/24 to the Internet. Gateway B's WAN (Internet) interface has the address 22.23.24.25. Gateway B's LAN interface address, 172.23.9.1, can be used for testing IPsec but is not needed for configuring Gateway A.

The IKE Phase 1 parameters used in Scenario 2 are:

- Main mode
- Triple DES
- SHA-1
- MODP group 2 (1024 bits)
- SA lifetime of 28800 seconds (eight hours) with no Kbytes rekeying

The IKE Phase 2 parameters used in Scenario 2 are:

- Triple DES
- SHA-1
- ESP tunnel mode
- MODP group 2 (1024 bits)
- Perfect forward secrecy for rekeying
- SA lifetime of 3600 seconds (one hour) with no Kbytes rekeying
- Selectors for all IP protocols, all ports, between 10.5.6.0/24 and 172.23.9.0/24, using IPv4 subnets

This configuration assumes you have already set up the XSR for basic operations (refer to the *XSR Getting Started Guide)*. Also, you should have generated a master key (see the *XSR User Guide).* To set up Gateway A for this scenario, perform the same steps as you would perform in Scenario 1, with one exception.

In Step 5, for authentication, select *RSA signatures* as follows:

```
XSR(config-isakmp)#authentication rsa-sig
```

After completing all 11 steps to configure the VPN, obtain a Root CA and personal certificate for this scenario by performing the following steps:

1. Begin by asking your CA administrator for your CA name and URL. The CA's URL defines its IP address, path and default port (80). You can resolve the CA server address manually by pinging its IP address.
2. Be sure that the XSR time setting is correct according to the UTC time zone so that it is synchronized with the CA's time. For example:

```
XSR#clock timezone -7 0
```

3. Specify the enrollment URL, authenticate the CA and retrieve the root certificate. Check your CA Website to ensure that the printed fingerprint matches the CA's fingerprint, which is retrieved from the CA itself, to verify the CA is not a fake. If bona fide, accept the certificate, if not, check to be sure the certificate is deleted and not stored in the CA database. In certain situations you may need to specify a particular CA identity name. Consult your administrator for more information.

```
XSR(config)#crypto ca identity hightest
XSR(config-ca-identity)#enrollment url http://192.168.1.33/certsrv/mscep/
mscep.dll/
XSR(config-ca-identity)#exit
XSR(config)#crypto ca authenticate PKItestca1

Certificate has the following attributes:
Fingerprint: D423E129 81904CE0 1E6D0FE0 A123A302
Do you accept this certificate? [yes/no] y
```

4. Display your CA certificates to verify all root and associated certificates are present. In the RA Mode example below, *Hightest* is the root CA of three certificates. Non-RA Mode CAs return one certificate only.

```
XSR(config)#show crypto ca certificates

CA Certificate - Hightest
 State:             CA-AUTHENTICATED
 Version:           V3
 Serial Number:     6083684655030387331394927502614112809
 Issuer:             C=US, O=sml, CN=hightest
 Valid From:        2002 Jun  4th, 12:40:46 GMT
 Valid To:          2004 Jun  4th, 12:48:15 GMT
 Subject:            C=US, O=sml, CN=hightest
 Fingerprint:       D423E129 81904CE0 1E6D0FE0 A123A302
 Certificate Size:  1157 bytes

RA KeyEncipher Certificate - Hightest-rae
 State:             CA-AUTHENTICATED
 Version:           V3
 Serial Number:     4581289352733669300635 30
 Issuer:             C=US, O=sml, CN=hightest
 Valid From:        2002 Jul 24th, 20:45:14 GMT
 Valid To:          2003 Jul 24th, 20:55:14 GMT
 Subject:            C=US, O=sml, sml_requestor
 Fingerprint:       F1279D63 AFFC3D93 48E5F311 73A1D16F
 Certificate Size:  1695 bytes

RA Signature Certificate - Hightest-ras
```

```
 State:              CA-AUTHENTICATED
 Version:            V3
 Serial Number:      458128729515158954573993
 Issuer:              C=US, O=sml, CN=hightest
 Valid From:         2002 Jul 24th, 20:45:13 GMT
 Valid To:           2003 Jul 24th, 20:55:13 GMT
 Subject:             C=US, O=sml.com, CN=sml_requestor
 Fingerprint:        91EB5A77 B5CA535A 077B65C5 65035615
 Certificate Size:   1695 bytes
```

5. Enroll in an end-entity certificate from a CA for which you have previously authenticated; e.g., *hightest*.

   The script will prompt you to enter and re-enter a challenge password you create or is given to you by your CA administrator. Remember that if you create a password, save it so it can be used later in case you need to revoke the CA. Respond yes to all questions. and jot down the certificate serial number for comparison purposes.

```
XSR(config)#crypto ca enroll hightest
%
% Start certificate enrollment
Create a challenge password. You will need to verbally
provide this password to the CA Administrator in order to
revoke your certificate. For security reasons your password
will not be saved in the configuration.
Please make a note of it.
Password:****
Re-enter password:****
Request certificate from CA (y/n) ? y
You may experience a short delay while RSA keys are generated.
Once key generation is complete, the certificate request
will be sent to the Certificate Authority.
Use 'show crypto ca certificate' to show the fingerprint.
XSR(config)#<186>Aug 29 7:11:1 192.168.1.33 PKI: A certificate was successfully
received from the CA.
<186>Nov 13 21:03:20 63.81.64.58 AAA: Current device Time: 2003 Nov 13th, 21:03:20 GMT
<186>Nov 13 21:03:20 63.81.64.58 AAA: Certificate valid from: 2003 Nov 13th, 21:57:02 GMT
<186>Nov 13 21:03:20 63.81.64.58 AAA: Certificate valid to: 2004 Aug  5th, 16:16:08 GMT
```

6. Once the certificate is properly enrolled, issue the **show crypto ca certificates** command to display the end-entity and other certificates.

   The first certificate shown, identified as being in ENTITY-ACTIVE state, is the end-entity certificate. Compare the Subject ID to the serial number earlier displayed by the enrollment script to verify its authenticity.

```
XSR#show crypto ca certificates

Certificate - issued by hightest
 State:              ENTITY-ACTIVE
 Version:            V3
 Serial Number:      75289387826578118934757
 Issuer:              C=US, O=sml, CN=hightest
 Valid From:         2002 Aug 29th, 15:51:58 GMT
```

```
 Valid To:          2003 Aug 29th, 16:01:58 GMT
 Subject:         unstructuredName=corp
 Fingerprint:       ABF37B67 7200CCDA 604CB10C D5AC7F49
 Certificate Size:  1590 bytes

CA Certificate - PKItestca1
 State:             CA-AUTHENTICATED
 Version:           V3
 Serial Number:     608368465503038733139492750261411280 9
 Issuer:             C=US, O=sml, CN=hightest
 Valid From:        2002 Jun  4th, 12:40:46 GMT
 Valid To:          2004 Jun  4th, 12:48:15 GMT
 Subject:            C=US, O=sml, CN=hightest
 Fingerprint:       D423E129 81904CE0 1E6D0FE0 A123A302
 Certificate Size:  1157 bytes

RA KeyEncipher Certificate - Hightest-rae
 State:             CA-AUTHENTICATED
 Version:           V3
 Serial Number:     4581289352733669300635 30
 Issuer:             C=US, O=sml, CN=hightest
 Valid From:        2002 Jul 24th, 20:45:14 GMT
 Valid To:          2003 Jul 24th, 20:55:14 GMT
 Subject:            C=US, O=sml, sml_requestor
 Fingerprint:       F1279D63 AFFC3D93 48E5F311 73A1D16F
 Certificate Size:  1695 bytes

RA Signature Certificate - Hightest-ras
 State:             CA-AUTHENTICATED
 Version:           V3
 Serial Number:     4581287295151589545739 93
 Issuer:             C=US, O=sml, CN=hightest
 Valid From:        2002 Jul 24th, 20:45:13 GMT
 Valid To:          2003 Jul 24th, 20:55:13 GMT
 Subject             C=US, O=sml, sml_requestor
 Fingerprint:       91EB5A77 B5CA535A 077B65C5 65035615
 Certificate Size:  1695 bytes
```

15

Configuring DHCP

Overview of DHCP

The Dynamic Host Configuration Protocol (DHCP) allocates and delivers configuration values, including IP addresses, to Internet hosts. Consisting of two components, DHCP provides host-specific configuration parameters from a DHCP Server to a host, and allocates network addresses to hosts. Recent extensions to the DHCP protocol extends high-availability, authenticated and QoS-dependent configuration of Internet hosts.

DHCP is based on the client-server model - a designated DHCP Server allocates network addresses and delivers configuration values to dynamically configured clients. Throughout this chapter, the term *server* refers to a host providing initialization values via DHCP, and the term *client* refers to a host requesting initialization values from a DHCP Server.

The XSR's DHCP Client implementation obtains IP addresses and configuration data for a *router interface* rather than a PC host. Be aware that DHCP Client cannot be configured on an XSR interface which already has a an IP address configured. Also, many capabilities and options typically supported by DHCP Client - SMTP, POP3 Server, many Microsoft-related options - are not supported. The Client silently ignores these options if it receives a DHCPOFFER /DHCPACK containing such parameters. Also, although the reply packet may contain a bootfile and server address field the DHCP Client will not initiate a TFTP file download in response to DHCPOFFER or DHCPACK.

DHCP allocates IP addresses in two ways:

- *Dynamic* allocation assigns an IP address to a client for a limited interval - lease - (or until a client explicitly relinquishes its address).
- *Manual* allocation involves a client IP address assigned by the network administrator, with DHCP used simply to convey the assigned address to the client.

DHCP messages are formatted similar to BOOTP messages to capture BOOTP Relay Agent behavior and allow existing BOOTP clients to interoperate with DHCP servers. DHCP is backward compatible with BOOTP (RFC-951). Implemented as an improvement to BOOTP, DHCP differs from BOOTP by its dynamically IP address allocation and lease definition capabilities.

Features

The XSR offers the following DHCP features:

- Persistent storage/database of network values for network clients.
- Persistent storage of network client lease states kept across reboot.
- Temporary or permanent network (IP) address allocation to clients.
- Network configuration parameter assignment to clients.

- Provisioning of differentiated network values by Client Class.
- Persistent and user-controllable conflict avoidance to prevent duplicate IP address including configurable ping checking.
- Visibility of DHCP network activity and leases through operator reports statistics and logs.
- Nested scopes.

DHCP Server Standards

The XSR supports the following:

- DHCP Server as defined in RFC-2131, *BOOTP Server* and *BOOTP Relay* as defined in RFC-951/RFC-1542, and *BOOTP Client* as defined in RFC-1534: *Interoperation Between DHCP and BOOTP* (static BOOTP only)
- DHCP Server also supports RFC-2132: *DHCP Options and BOOTP Vendor Extensions* and RFC-3004: *User Class Option for DHCP*.
- DHCP Server and DHCP/BOOTP Relay services run on FastEthernet ports *only*.

> **Note:** If either DHCP/BOOTP Relay (using the **`ip helper-address`** command) or DHCP Server is enabled on one FastEthernet port, you cannot also configure the other service on the second FastEthernet port. The XSR permits either one or the other service to operate, not both.

How DHCP Works

The DHCP client-server model defines a set of messages exchanged between two systems. A simplified description of client-server communications follows:

1. A client issues a broadcast message (DISCOVER) to locate available DHCP Servers on its local subnet. This message may include suggested values for the *network address* and duration of a *lease*. Also, BOOTP relay agents may pass the message on to DHCP Servers not on the same physical subnet.
2. A response (OFFER) is sent from a DHCP Server to the client with an offer of configuration parameters including an available network IP address and settable options. Before the server actually allocates the new address, it will check that the address is free by pinging it.
3. A client sends a message (REQUEST) to servers for one of the following purposes:
   - Requesting offered parameters from one server and implicitly declining offers from all others,
   - Confirming the correctness of a previously allocated address after, for example, a system reboot,
   - Extending the lease on a particular network address.
4. The selected server sends a message (ACK) to a client with configuration parameters - a *binding* - including a committed network address, *client-identifier* or *hardware-address* and commits its lease to the binding database. Or, the server sends a message (NACK) indicating the client's idea of a network address is incorrect or the client's lease has expired.
5. The client performs a final check (ARPs the allocated network address) on the parameters and at this point is configured.
6. The client may relinquish its lease on a network address by sending a message (RELEASE) to the server identifying the lease with its *client identifier* (hardware/network addresses). If the

client used a client ID when it got the lease, it will use the same identifier in the message. Alternately, when a lease is near expiration, the client tries to renew it. If unsuccessful in renewing by a certain period, the client enters a rebinding state and sends a DISCOVER message to restart the process.

DHCP also sets various options/extensions to clients which are outlined in "Assigned Network Configuration Values to Clients: Options" on page 15-3.

DHCP Services

The DHCP services comprising the Bindings Database, leases, network options, and Client Class configuration are described below.

Persistent Storage of Network Parameters for Clients

The first DHCP service is persistent storage of network parameters for network clients, also known as the *bindings database*. The XSR directs the Server to store a [*key*:*value*] entry for each client, where the *key* is some unique identifier and the *value* contains configuration parameters for the client.

For example, the key might be the *IP-subnet-number/hardware-address* pair. Alternately, the key might be the *IP-subnet-number/hostname* pair, allowing the server to assign parameters intelligently to a DHCP client that has been moved to a different subnet or has changed hardware addresses. DHCP defines the key to be *IP-subnet-number/hardware-address* unless the client explicitly supplies an identifier using the *client identifier* option. The XSR stores host IP and client-hardware addresses, intervals, client-identifiers, and client-names in the **`leases.cfg`** file.

Temporary or Permanent Network Address Allocation

The second DHCP service is temporary or permanent network (IP) address allocation to clients. Network addresses are dynamically allocated simply by a client requesting an address for an interval with the server guaranteeing not to reallocate that address within the requested time and attempting to return the same network address each time the client requests an address.

Lease

The period over which a network address is allocated to a client is called a *lease*. A client may extend its lease with follow-up requests and may issue a message to release the address back to the server when the address is no longer needed. Also, a client may request a *permanent* assignment by asking for an *infinite* lease. Even if it assigns permanent addresses, a server may distribute lengthy but non-infinite leases to allow detection of a retired client.

In some environments network addresses must be reassigned due to exhaustion of available addresses in which case the allocator reuses addresses whose leases have expired. The server will use any available data in the configuration data repository to choose an address for reuse.

For example, the server may choose the least recently assigned address. As a consistency check, the allocating server will also probe the reused address before allocating the address - e.g., with an ICMP echo request - and the client will also probe the newly received address - e.g., with ARP.

Assigned Network Configuration Values to Clients: Options

With the exception of IP address assignment to clients, the DHCP Server provides a framework for passing configuration data to hosts on a TCP/IP network. Configuration values and other

control data are carried in tagged data items which are stored in the *options* field of the DHCP message. The data items themselves, also called *options,* are enabled on the XSR by the **`options`** command specifying IP address, hex or ASCII string values. Supported options are defined in the "*Dynamic Host Configuration Protocol Commands*" chapter of the *XSR CLI Reference Guide*.

RFC-1122 specifies default values for most IP/TCP configuration parameters.

Provisioning Differentiated Network Values by Client Class

One DHCP option - supported on the XSR by the **`client-class`** command - groups clients into classes with differentiated configuration. A DHCP Server selects appropriate parameters for the clients belonging to this class. For example, a Client Class can configure all enterprise users in *Accounting* with a different lease time than users in *Marketing*. RFC-3004 defines the User Class (Client Class) option for DHCP.

BOOTP Legacy Support

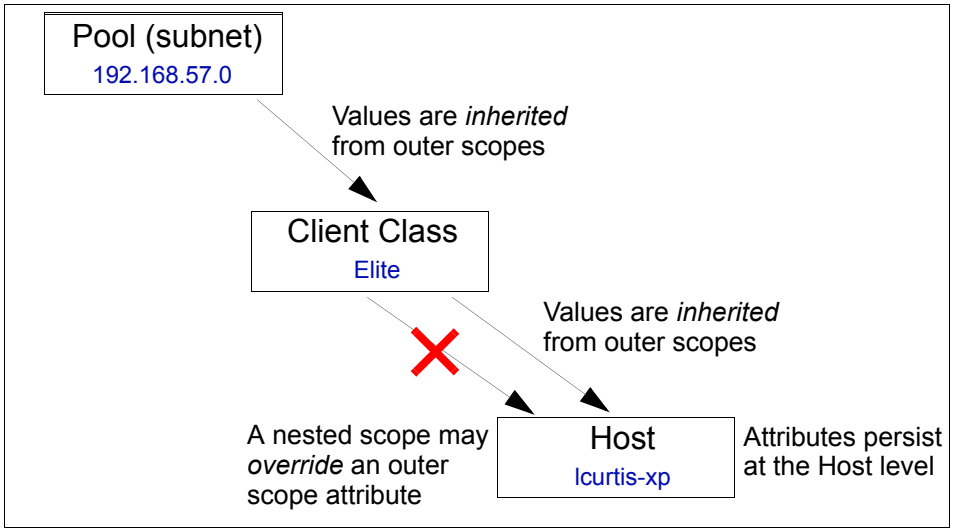
The XSR provides backward compatibility with BOOTP clients. When configured with a manual binding, it supplies a specified IP address to the client as well as a TFTP server IP address and file name to download (with the **`next-server`** command).

Refer to "BOOTP Client Support Example" on page 15-12 for more information.

Nested Scopes: IP Pool Subsets

As mentioned earlier, one of the main functions of the DHCP Server is to allocate IP addresses to clients. In that process, the DHCP Server works with three *scopes* or resource sets responsible for aggregated DHCP attributes - *Pools* or subnets, *Client Classes*, and *Hosts*. Scopes can be assigned other attributes as well as IP addresses, and can nest these attributes hierarchically much like files are organized in a directory tree. How these scopes interrelate can be loosely illustrated as shown in Figure 15-1.

Figure 15-1 DHCP Nested Scopes



The Pool scope in Figure 15-1 defines and manipulates IP addresses and parameters. The Client Class scope manages sets of clients requesting DHCP Server services. The Host scope controls DHCP user parameters.

When DHCP Server surveys its clients using the manual bindings of a *client-identifier* or *hardware-address*, and *host* address, it generally *inherits* attributes from an outer down to an inner scope. But, the DHCP Server will *override* outermost attributes when they are found *first* at the Host scope.

For instance, if a **`domain-name`** is specified for *lcurtis-xp* in the Host scope and another domain-name in the Pool scope for all clients on the *192.168.57.0* network, DHCP Server always select the Host scope attribute.

Scope Caveat

Keep the following caveat in mind when configuring scopes: IP address pools may not be configured to overlap. The following conditions apply:

- IP local pools may have multiple DHCP Servers per subnet for redundancy
- Each DHCP Server should have a unique address pool that does not overlap pools on other DHCP servers

For example, a correct IP range would be configured as follows: on subnet 90.1.1.0/24, the DHCP Server A range can be from 90.1.1.1 to 90.1.1.150, and the DHCP Server B range can be from 90.1.1.151 to 90.1.1.254

Manual Bindings

An address binding is a mapping between the IP address and MAC address or Client-ID of a client. You can manually assign the IP address of a client or have it assigned automatically from a pool by a DHCP Server.

Manual bindings are IP addresses that have been manually mapped to the MAC addresses of hosts recorded in the DHCP database. An unlimited number of manual bindings are stored in *startup-config*. Automatic bindings are IP addresses that have been automatically mapped to the MAC addresses of hosts recorded in the DHCP database. Automatic bindings are saved in persistent storage in the **`leases.cfg`** file.

Manual bindings are set up by first creating a *host* pool, then specifying the IP address of the client and *hardware-address* or *client-identifier*. The hardware address is the MAC address. The client identifier, which is required for Microsoft clients (instead of a hardware address), is formed by concatenating the media type and the MAC address of the client.

To configure manual bindings, perform the following steps:

1. Enter **ip dhcp pool <name>** to create a name for the a DHCP Server address pool and acquire DHCP pool configuration mode.
2. Enter **host address [mask | prefix-length]** to specify the client's IP address and subnet mask.

   The prefix length sets the number of bits that comprise the address prefix. The prefix is an alternative to specifying the network mask of the client. The prefix length must be preceded by a forward slash (/).
3. Perform one of the following actions:

   a. Specify a hardware address for the client. Enter:

   ```
   hardware-address <hardware-address> <type> client-class <name>
   ```

   or

   b. Specify the distinct identification of the client in dotted hexadecimal notation; e.g., *01b7.0813.8811.66*, where *01* represents the Ethernet media type. Enter:

   ```
   client-identifier <unique-identifier> client-class <name>
   ```

Note: Manual bindings can be added by performing steps 2 and 3 in any order. But, when deleting a binding, enter the *no* form of the command (**host**, **hardware-address** or **client-identifier**) entered *first* when created.

4. Optionally, specify the client name using any standard ASCII character.
   Enter **client-name <name>**.

   The client name should not include the domain name. For example, the name *acme* should not be specified as *acme.enterasys.com*.

DHCP Client Services

Router Option

The XSR's DHCP Client implementation supports Router Option (DHCP Option 3). When one or more host IP addresses exist in the Router Option, the first host IP address will be used as the default IP route. The following sample debug level logging message is generated:

```
XSR-1200 DHCP: Set IPA (192.168.70.102/24) and Default Gateway (192.168.70.1) on
interface FastEthernet0
```

Such a route with a cost of 254 is entered in the routing table and can be displayed by the **show ip route** command as follows:

```
XSR-1200#show ip route
Codes: C-connected, S-static, R-RIP, B-BGP, O-OSPF, IA-OSPF interarea
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - 0SPF external type 1, E2 - 0SPF external type 2, H-DHCP default
* - candidate default, D - default route originated from default net
  C    192.168.70.0/24         [  0/0001] directly connected, FastEthernet0
* H    0.0.0.0/0               [254/0001] via 192.168.70.1, FastEthernet0
```

This route will be reset and deleted from the routing table if this particular interface is down or the DHCP lease expires and can not be renewed. A logging message will be generated as follows:

```
XSR-1200#<191>Jan  2 00:24:54 XSR-1200 DHCP: Zero IPA and Clear Default Gateway
(192.168.70.1) on interface FastEthernet0
```

Parameter Request List Option

DHCP Option 55 is used by the DHCP Client to request values for specific configuration parameters. Currently, this list is not configurable; the default value is the *Subnet Mask*.

Note: Although *Routers*, *Domain Name*, and *Hostname* values are typically included in Option 55, these are not used by this client unless the client is part of RAI.

DHCP Client Interaction

Secondary Address Caveats

DHCP negotiation and secondary addresses are mutually exclusive on the XSR. An interface configured with secondary addresses cannot be switched to DHCP negotiation and an interface configured for DHCP negotiation will reject any secondary address commands.

Primary and secondary IP addresses on the same interface are not permitted within the same subnet nor are they allowed within the same subnets already occupied by other interfaces. Also, the primary IP address must be configured before any secondary address is configured. If the primary address is DHCP negotiated, its address and mask are unknown until a DHCP server supplies such addresses.

Interaction with Remote Auto Install (RAI)

When DHCP Client negotiation is conducted during the RAI operations, minor differences occur in comparison to how the functionality behaves otherwise. The *Parameters Request List* will contain the following:

- Subnet Mask
- Routers
- Domain Name Servers
- Host Name
- Bootfile Name
- TFTP Server Address

A timer starts when DHCP Client is created on an interface. Upon the timer's expiration, DHCP Client shuts down, informing RAI that address negotiation has failed and, in this case, is never restarted. RAI then attempts auto install on other interfaces.

In addition to RAI obtaining the address/mask in conventional fashion, the following data is also obtained when available:

- hostname of the router - (Option 12)
- file name (in order of preference) - file field or Option 67 (Bootfile Name)
- IP address of the TFTP server (in order of preference) - Option 150 (TFTP Server address) or *siaddr* field

For more information on RAI, refer to "Managing the XSR" on page 2-1.

DHCP Client Timeouts

The XSR supports the following default FSM (Finite State Machine) timeouts:

Table 15-3 FSM Timeouts

Timeout	Default	Description
Retry interval	300 seconds	Interval to re-enter Initial State if no lease
Select interval	0 seconds (accepts first valid response)	Interval to accumulate OFFER messages from different servers
Reboot timeout	10 seconds	Interval to enter Initial State from Rebooting State if no ACK/NAK received
Initial interval	3 seconds	Exponential backoff period starting with this value
Backoff cutoff	15 seconds	Peak backoff period

DHCP CLI Commands

The XSR offers CLI commands to provide the following functionality:

- DHCP Server address pool(s) with related parameters and DHCP options/vendor extensions. You can configure a DHCP address pool with a name that is a symbolic string (e.g., Accounting) with **`ip dhcp pool`**. Configuring a DHCP address pool also places you in DHCP pool mode - **`(config-dhcp-pool)#`** - from which you can configure pool parameters. The XSR supports adding 1000 network addresses per pool and one DHCP pool per network.
- Create manual bindings of IP addresses and client hardware addresses - Manual bindings are comprised of a:
  - *host* - the DHCP client's IP address and subnet mask or prefix length, entered with **`host`**
  - *hardware-address* - the DHCP client's MAC address and platform protocol, entered with **`hardware-address`**, or
  - *client-identifier* - the DHCP client's unique marker is its combined media type and MAC address, entered with **`client-identifier`**.
- Delete client bindings from the DHCP Server. **`Clear ip dhcp binding`** removes an automatic address binding from the DHCP database; **`no host, no hardware-address`** or **`no client-id`** remove manual bindings depending on which command was entered first when the binding was created.
- DHCP Server boot file(s) - The boot file is used to store a boot image for the client. The boot image is often the operating system a client uses to load. It is configured with **`bootfile`**.
- Enable BOOTP Relay by configuring a destination address for UDP broadcasts with **`ip helper-address`**.
- Set domain name and DNS server - To put a client in the general group of networks comprising the domain, use **`domain-name`**. To specify the DNS server clients query when they need to correlate host names to IP addresses, use **`dns-server`**.
- Specify the NetBIOS server and node type for Microsoft clients - DHCP clients query DNS servers when they must resolve host names to IP addresses; enter an IP address of the NetBIOS MS WINS server using **`netbios-name-server`**. The XSR supports four node types of DHCP clients: broadcast, peer-to-peer, mixed, and hybrid. They can be specified using **`netbios-node-type`**.
- Configure a default router for the client - After a DHCP client has booted, the client begins sending packets to its default router. The IP address of the default router is required and should be on the same subnet as the client. Set using **`default-router`**.
- Configure the address lease time - IP addresses assigned by a DHCP Server have a one-day lease - the interval during which the address is valid. Specify with **`lease`**.
- Set the number of ping packets and ping wait interval - the DHCP Server pings an IP address twice before assigning a particular address to a requesting client. If the ping is unanswered, the server assumes (with a high probability) that the address is not in use and assigns the address to the requesting client. Use **`ip dhcp ping packets`** to change the number of ping packets the server should send to the IP address before assigning the address.
- Use **`ip dhcp ping timeout`** to specify the period the server must wait before timing out a ping request.
- Monitor and maintain DHCP Server services by issuing the following **`show`** commands. **`Show ip dhcp bindings`** displays bindings data on the DHCP Server including lease expiration dates. **`Show ip dhcp conflict`** displays address conflicts found by a DHCP Server when

addresses are offered to the client. **`Show ip dhcp server statistics`** is a useful catch-all command. **`Show ip local pool`** shows a list of active IP local pools, excluded and in use IP addresses.

DHCP Set Up Overview

Configuring DHCP Address Pools

The DHCP Server is configured by performing the following:

- Allocate one or more address pools for DHCP clients. These pools can specify addresses on the local subnets of the router or external subnets whose clients reach the DHCP Server using BOOTP Relay.
- Exclude any addresses from these pools which must restricted and map to the DHCP pool.
- For each pool, define the set of DHCP network configuration values to be supplied to clients.
- Add manual (static) bindings to the DHCP pool configuration.
- Enable the DHCP Server on a FastEthernet interface *only*.

Configuring DHCP - Network Configuration Parameters

The DHCP Server can supply network configuration parameters; e.g., the IP address of the DNS Server to its clients.

A DHCP client may require a large set of configuration parameters. Likewise, a network may contain a variety of different client types, each needing a different (possibly unique) set of network parameters.

The XSR's DHCP setup is minimized for elaborate configuration by the use of *scopes*.

Configuration Steps

Only four steps are required to minimally configure DHCP Server. They are:

- Create an IP Local Client Pool
- Create a Corresponding DHCP Pool
- Configure DHCP Network Parameters
- Enable the DHCP Server

Optionally, you can also:

- Set up a DHCP Nested Scope
- Configure a DHCP Manual Binding

These steps are described in the following sections.

Create an IP Local Client Pool

Begin DHCP configuration by specifying a pool of IP addresses for clients on a local or remote subnet (set via BOOTP Relay Agent). For this example, the local interface is assigned IP address 1.1.1.2 255.255.255.0.

1. Add global pool *local_clients* including the starting IP address of the range and addresses that are unreachable to network clients:

```
XSR(config)#ip local pool local_clients 1.1.1.0/24
XSR(ip-local-pool)#exclude 1.1.1.249 6
```

Create a Corresponding DHCP Pool

2. Map this local pool to a DHCP pool by specifying the correct name:

```
XSR(config)#ip dhcp pool local_clients
```

Configure DHCP Network Parameters

3. On the pool just supplied to DHCP, define some attributes for network clients. They include the lease duration (dynamic leases) of two hours and 30 minutes, IP addresses of the default router and DNS server (these IP addresses derive from the excluded address range on the IP local pool), and the *Enterasys.com* domain name.

```
XSR(config-dhcp-pool)#lease 0 2 30
XSR(config-dhcp-pool)#default-router 1.1.1.249 1.1.1.250
XSR(config-dhcp-pool)#dns-server 1.1.1.254
XSR(config-dhcp-pool)#domain-name ets.enterasys.com
```

Note: Some values can also be configured for a Client-Class or Host scope.

Enable the DHCP Server

4. Initialize the DHCP Server on FastEthernet interface 2:

```
XSR(config)#interface fastethernet 2
XSR(config-if<F2>#ip dhcp server
```

Optional: Set Up a DHCP Nested Scope

5. Continue configuring *local_clients* by creating a named client-class and using it to override the lease time. Clients presenting this name in DHCP messages will get the shorter lease time but will continue to receive *dns-server* and other values defined in the pool.

```
XSR(config)#ip dhcp pool local_clients
XSR(config-dhcp-pool)#client-class class1
XSR(config-dhcp-class)#lease 0 0 30
```

6. Extend the client-class attributes to include the address of a NetBIOS-name-server:

```
XSR(config-dhcp-class)#netbios-name-server 1.1.1.253
```

Optional: Configure a DHCP Manual Binding

7. Add a manual binding in the local_client pool:

```
XSR(config-dhcp-class)#host 1.1.1.7 255.255.255.0
XSR(config-dhcp-host)#hardware-address 1111.2222.3333 1
```

8. Add to the host scope by specifying the NetBIOS-node-type for this particular host:

```
XSR(config-dhcp-host)#netbios-node-type h-node
```

9. Specify any numbered options. For example, setting DHCP option 28 specifies the broadcast address in use on the client's subnet:

```
XSR(config)#ip dhcp pool local_clients
XSR(config-dhcp-pool)#option 28 ip 255.255.255.255
```

DHCP Server Configuration Examples

The following examples configure DHCP with different options. For DHCP implementations with firewall configured, refer to "Configuring Security on the XSR" on page 16-1.

Pool with Hybrid Servers Example

In the following example, the single DHCP pool *dpool* is created and two default routers defined: 168.16.22.100 (higher preference) and 168.16.22.101 (lower preference). The domain name *enterasys.com* is specified and a list of two DNS servers defined - 168.16.33.102 (higher) and 168.16.33.103 (lower). NetBIOS servers are specified as type hybrid - 168.16.44.103 (higher) and 168.16.44.104 (lower). Finally, the lease time for all clients is limited to 10 days.

```
XSR(config)#ip local pool dpool 168.16.22.0/24
XSR(config)#ip dhcp pool dpool
XSR(config-dhcp-pool)#default-router 168.16.22.100 168.16.22.101
XSR(config-dhcp-pool)#domain-name enterasys.com
XSR(config-dhcp-pool)#dns-server 168.16.33.102 168.16.33.103
XSR(config-dhcp-pool)#netbios-name-server 168.16.44.103 168.16.44.104
XSR(config-dhcp-pool)#netbios-node-type h-node
XSR(config-dhcp-pool)#lease 10
```

Manual Binding Example

In this example, the single DHCP pool *dpool* is created with a domain name *enterasys.com*. A host is defined with MAC address 00:f0:12:11:22:a1 in dotted decimal format and a manual binding is specified by IP address 1.1.1.20 and mask 255.255.255.0. The domain name for this host is specified as *ent.com* (this will override *enterasys.com* specified for this pool).

```
XSR(config)#ip local pool dpool 1.1.1.0/24
XSR(config)#ip dhcp pool dpool
XSR(config-dhcp-pool)#domain-name enterasys.com
XSR(config-dhcp-pool)#hardware-address 00f0.1211.22a1
XSR(config-dhcp-host)#host 1.1.1.20 255.255.255.0
XSR(config-dhcp-host)#domain-name ent.com
```

Manual Binding with Class Example

In the following example, the single DHCP pool *dpool* is created with the domain name *enterasys.com.* A class *engineering* is defined. The domain name for all hosts is *ent.com*. A host is defined with a MAC address in dotted decimal format. A manual binding is specified by IP address 1.1.1.20 and mask 255.255.255.0.

The domain name for this host is specified as *indusriver.com* (this will override *enterasys.com* specified for this pool, and *ent.com* specified for the class).

```
XSR(config)#ip local pool dpool 1.1.1.0/24
XSR(config)#ip dhcp pool dpool
XSR(config-dhcp-pool)#domain-name enterasys.com
XSR(config-dhcp-pool)#client-class engineering
XSR(config-dhcp-class)#domain-name ent.com
XSR(config-dhcp-class)#hardware-address 00f0.1211.22a1
XSR(config-dhcp-host)#host 1.1.1.20 255.255.255.0
XSR(config-dhcp-host)#domain-name indusriver.com
```

BOOTP Client Support Example

In the following example, the XSR is configured to support a BOOTP client to download an image file from a TFTP server. Configured within the DHCP pool *BOOTPdownload*, the client is assigned a manual binding of *host* IP and *hardware addresses* (or optionally, its *client-id*), the TFTP server's IP address, and the name of the file to be downloaded, *acme.hex*. Also, a static ARP entry is set.

```
XSR(config)#ip dhcp pool BOOTPdownload
XSR(config-dhcp-pool)#host 192.168.1.33 255.255.255.0
XSR(config-dhcp-pool)#next-server 192.168.1.234
XSR(config-dhcp-pool)#bootfile acme.hex
XSR(config-dhcp-pool)#hardware-address 0000.1d11.e829
XSR(config)#arp 192.168.1.33 0000.1D11.E829
```

When the MAC address *0000.1d11.e829* (BOOTP client) transmits a BOOTP request, the DHCP server will respond with the IP address *192.168.1.33*, the boot file name *acme.hex* and the next-server IP address *192.168.1.234.*

DHCP Option Examples

The following sample DHCP option configurations illustrate the three types of option values prompted for by the CLI: IP address, ASCII and hex. See the *XSR CLI Reference Guide* for more.

The following example configures DHCP option 3, which lists the IP addresses of four default routers on the DHCP client's subnet in descending order of preference. This setting can also be configured by the DHCP **`default-router`** command. Be sure to first exclude these addresses from the IP local pool to prevent them from being allocated by the DHCP server.

```
XSR(config-dhcp-pool)#option 3 ip 192.168.57.90 192.168.57.26 192.168.57.54 192.168.57.78
```

The following example configures DHCP option 12, which specifies the host name of a client which may or may not be qualified with the local domain name. The option parameter is expressed in ASCII text but can also be configured by the DHCP **`client-name`** command. The name should *not* include the domain name.

```
XSR(config-dhcp-host)#option 12 ascii jonah
```

The following example configures DHCP option 29, which specifies that the client will perform subnet mask discovery using ICMP.

```
XSR(config-dhcp-host)#option 29 hex 01
```

16

Configuring Security on the XSR

This chapter describes the security options available on the XSR including the firewall feature set and methods to protect against hacker attacks.

Features

The following security features are supported on the XSR:

- Standard and Extended Access Control Lists (ACLs)
- Protection against: LANd attack - Destination IP equals Source IP, ICMP echo to directed subnet, UDP echo request to directed subnet broadcast, SYN flood, FIN attacks
- IP packet with multicast/broadcast source address
- Spoofed address checking
- TCP server resource release
- ICMP traffic filtering based on IP data length, IP offset, IP fragmentation bits including:
  - Fragmented ICMP traffic
  - Large ICMP packets
  - Ping of Death attack
- Filter TCP traffic with SYN and FIN bits set
- AAA services including AAA per port, interface privilege levels, PPP client of AAA, debugging
- Firewall feature set

Note: Activating any of the above features will affect system performance.

Access Control Lists

Access Control Lists (ACL) impose selection criteria for certain types of packets, which when used in conjunction with other functions restrict Layer 3 traffic on the XSR. They are configured as:

- Standard access lists (1-99) restrict traffic based on *source IP addresses*
- Extended access lists (100-199) filter traffic from *source* and *destination IP addresses*, *protocol type* (ICMP, TCP, UDP, GRE, ESP, AH), *port number* ((TCP, UDP), and *type/code* (ICMP)

To configure ACLs, you *define* them by number only then *apply* them to an interface. Any number of entries can be defined in a single ACL and may actually conflict, but they are analyzed in the order in which they appear in the **`show access-lists`** command.

Input and output filters are applied separately and an interface can have only one ACL applied to its input side, and one to its output side. Also, the ACL netmask is complemented. For example, 0.0.0.255 indicates that the least significant byte is ignored.

The XSR implementation of ACLs is limited by the following conditions:

- The total number of ACL entries allowed is 500.
- For crypto maps and ACLs applied to the same interface, the XSR gives precedence to the crypto map, which is always consulted before the ACL on a port for both inbound and outbound traffic. If IPSec encrypts or decrypts packets due to the crypto map configuration then the ACL is ignored.

The XSR can log ACL violations on a per-source IP, per-ACL group basis and periodically display a packet counter with the **`access-list log`** command. ACL violations logging is updated every five minutes but, as an alternative, you can control the log based on the number of packets denied or permitted with the **`access-list log-update threshold`** command. The functionality is applied to both standard and extended control lists. After the update is reported, the log is cleared for the entry with that source IP and ACL group.

Be aware that router performance will be affected by copying packet information for logging alarms and displaying alarms once every five minutes. Also, when reporting is enabled for every packet and too many packets must be logged, some message loss may occur due to flooding.

ACL Violations Alarm Example

The ACL violations alarm displays the *ACL group* (encompassing all ACL entries for that number), *permit/deny* action, *source IP* address and number of *packets* that arrived in the last five minutes. For example, if 11 packets originate from the server at IP address 15.15.15.2 and 20 packets derive from the server at IP address 21.21.7.5 with the following CLI configuration:

```
XSR(config)#access-list 101 deny ip 15.15.15.0 0.0.0.255 16.16.16.0 0.0.0.255 log
XSR(config)#access-list 101 permit ip 21.21.0.0 0.0.255.255 any any log
```

The first alarms logged will display as follows:

```
XSR(config)#access-list 101 deny 15.15.15.2 1 packet
XSR(config)#access-list 101 permit 21.21.7.5 1 packet
```

After five minutes, the alarms logged will display as follows:

```
XSR(config)#access-list 101 deny 15.15.15.2 10 packets
XSR(config)#access-list 101 permit 21.21.7.5 19 packets
```

Packet Filtering

Packet filtering is configured via standard and extended **`access-list`** commands. For more information, refer to the *XSR CLI Reference Guide*.

LANd Attack

Protection against LANd attacks is triggered when a packet arrives with the IP source address equal to the IP destination address. This is an illegal IP packet and it is discarded by the XSR when the protection is enabled with the **`HostDos`** command. See the Firewall section for more details.

Smurf Attack

A “smurf” attack involves an attacker sending ICMP echo requests from a falsified source (a spoofed address) to a directed broadcast address, causing all hosts on the target subnet to reply to the falsified source. By sending a continuous stream of such requests, the attacker can create a much larger stream of replies, inundating the host whose address is being falsified.

The XSR protects against smurf attacks by turning off directed broadcast and turning on check-spoofing. Refer to “Configuring IP” on page 5-1 and the *XSR CLI Reference Guide* for more information on IP directed broadcast.

Fraggle Attack

A “fraggle” attack involves a UDP Echo-directed broadcast. It is similar to a smurf attack but differs in that it uses UDP instead of ICMP packets.

The XSR protects against a fraggle attack by turning off directed broadcast and turning on check-spoofing. Refer to “Configuring IP” on page 5-1.

IP Packet with Multicast/Broadcast Source Address

This type of attack involves an illegal IP packet. Because XSR interfaces are programmed to discard these packets, no user configuration is necessary.

Spoofed Address Check

This feature allows spoofing of IP source addresses by checking the source address of a packet against the routing table to ensure the return path of the packet is through the interface it was received on.

SYN Flood Attack Mitigation

Also known as a Denial of Service (DoS) attack, this involves a hacker flooding a server with a barrage of requests for access to unreachable return addresses. Since the return addresses are unreachable, the connections cannot be built and the ensuing volume of unresolved open connections eventually overwhelms the server, causing service denial to valid requests. A SYN flood attack against the XSR is defended by the router not checking transit packets.

This feature is always enabled, and the maximum number of TCP sessions allowed is set at run time, depending on the number of TCP applications running, and the maximum number of sessions each of them could have. Any connection attempt above this number is denied.

Fragmented and Large ICMP Packets

The XSR offers these features to filter ICMP traffic based on IP data length, IP offset, and IP fragmentation bits. They apply to packets destined for the XSR. Transit packets will not be checked.

Fragmented ICMP Traffic

This protection is triggered for ICMP packets with the “more fragments” flag set to 1, or an offset indicated in the offset field. Such packets are dropped by the XSR if the protection is enabled with the **`HostDoS`** command.

Large ICMP Packets

This protection is triggered for ICMP packets larger than a size you can configure. Such packets are dropped by the XSR if the protection is enabled with the **`HostDoS`** command.

Ping of Death Attack

This protection is triggered when an ICMP packet is received with the "more fragments" bit set to 0, and ((IP offset * 8) + IP data length) greater than 65535. As the maximum size for an IP datagram is 65535, this could cause a buffer overflow. The XSR always drops such packets automatically.

Spurious State Transition

Protection against spurious state transition concerns TCP packets with Syn and Fin bits set. This type of attack occurs when an intruder attempts to stall a network port for a very long time, using the state transition from state SYN_RCVD to CLOSE_WAIT, by sending a packet with both SYN and FIN flags set to a host.

The host first processes the SYN flag, generates the ACK packet back, and changes its state to SYN_RCVD. Then it processes the FIN flag, performs a transition to CLOSE_WAIT, and sends the ACK packet back.

The attacker does not send any other packet, and the state machine of the host remains in CLOSE_WAIT state until the keep-alive timer resets it to the CLOSED state. To protect against this attack the XSR checks for TCP packets with both SYN and FIN flags set. With protection always enabled, these packets are harmlessly dropped.

This feature is supported for packets destined for the XSR. Transit packets will be checked.

General Security Precautions

To ensure security on the XSR, we recommend you take these precautions:

- Limit physical access
- Avoid connecting a modem to the console port
- Download the latest security patches
- Retain secured backup copies of device configurations
- Plan all configuration changes and prepare a back-out procedure if they go wrong
- Keep track of all configuration changes made to all devices
- Create a database that tracks the OS version, description of last change, back-out procedure, and administrative owner of all routers
- Avoid entering clear text passwords in the configuration script
- Be sure to change all default passwords
- Use strong passwords not found in the dictionary
- Change passwords when the IT staff departs
- Age passwords after 30 to 60 days
- Grant the correct privilege levels to particular users only
- Set reasonable timeouts for console and remote management sessions

- If you must enable PPP on the WAN, use CHAP authentication
- Disable all unnecessary router services (e.g., HTTP, if not used)
- Write strict ACLs to limit HTTP, Telnet and SNMP access
- Write ACLs to limit the type of ICMP messages
- Create ACLs to direct services to appropriate servers only
- Enable packet filtering and attack prevention mechanisms
- All only packets with valid source addresses to exit the network
- If using SNMP, use strong community names and set read-only access
- Minimize console logging to limit unnecessary CPU cycles
- Use OSPF rather than RIP to take advantage of MD5 authentication
- Control which router interfaces can be used to manage the XSR
- Use an SNTP server on the DMZ to synchronize XSR clocks
- Use syslog to send messages to a designated syslog server

AAA Services

The XSR provides Authentication, Authorization and Accounting (AAA) services to validate and display data for AAA usergroups, users, and methods. Telnet, Console and SSH users can utilize the following two authentication mechanisms:

- *CLI database authentication* - This non-AAA authentication mode for Telnet and SSH users authenticates against the CLI database created by the **`username`** command. This is the base, system default user-validation method and does not authenticate via RADIUS.
- *AAA user database authentication* - This mechanism allows Telnet and SSH avails users of the AAA module which provides additional authentication by various AAA methods including RADIUS. The **`aaa client telnet`** command switches all Telnet users to authenticate via the AAA user database while **`aaa client ssh`** switches all SSH users to do the same.

A few restrictions apply when switching Telnet, Console and SSH users to authenticate via this mechanism, as follows:

- No pre-existing privilege-15 *admin* user exists in the AAA database.
- Before switching over to AAA for Telnet or SSH, at least *one* privilege 15 user with a Telnet/SSH policy must exist in the AAA database.
- Deleting the only privilege-15 user with Telnet or SSH policy is disallowed to prevent any accidental loss of access to the XSR.

The XSR offers two types of default AAA *methods*:

- The *default* AAA method for AAA service. Although the *local* method is the factory default, you can set this using the **`aaa method`** [**`local`** | **`pki`** | **`radius`**] **`default`** command.
- The default AAA method for grouped *clients*. This is set on a per client basis via the **`client`** {**`telnet`** | **`ssh`** | **`console`** | **`firewall`** | **`vpn`** | **`ppp`**} sub-command under **`aaa method`**. Note that PPP uses only AAA when acting as the authenticator (when validating the peer); PPP is authenticated *by* the peer when acting as the authenticatee (client-side).

If the latter default method is not specified for a client, the former default applies.

The method to perform AAA is configured *globally* by the **aaa method** command, which provides additional **acct-port**, **address**, **attempts**, **auth-port**, **backup**, **client**, **enable**, **group**, **hash enable**, **key**, **qtimeout**, **retransmit**, and **timeout** sub-commands. Although the default AAA service is *local*, you can authenticate to a RADIUS server or PKI database. Alternately, you can set the AAA method *per interface* with **aaa-method**, which lets the XSR authenticate requests originating from different interfaces by different methods and overrides the global (invoked by **client**) *or* default AAA method. For example, if the default method has not been set for Telnet using **client telnet**, then the default method you set for AAA service is used.

Most AAA method sub-commands are available for RADIUS service only (see "Firewall Configuration for RADIUS Authentication and Accounting" on page 16-33). Additional AAA method sub-commands **acct-port** and **auth-port** set UDP ports for accounting and authentication requests, respectively.

AAA *users* can be added to AAA service with the **aaa user** command, which includes **group**, **ip address**, **password**, **privilege**, and **policy** sub-commands to set user attributes. Also, you can set a maximum privilege level *per interface* to supersede any user/group-assigned level.

While most of these parameters are self-explanatory, the **policy** value is important in specifying which system each user will be allowed to access on the XSR. The module options are: **firewall**, **ssh**, **telnet**, and **vpn**. Their intended functions are, as follows:

- *Telnet/Console*: administrators and low-level Console users who will use the standard serial connection application
- *SSH*: users who will require a more secure Telnet-type connection
- *Firewall*: users who will access the firewall
- *VPN*: users who will tunnel in to the XSR

AAA users can be assigned to *groups* with the **aaa group** top-level command, which is sub-divided into **dns** and **wins server**, **ip pool**, **l2tp** and **pptp compression**, **pptp encrypt mppe**, **privilege**, and **policy** sub-commands to set that group's respective parameters. Any users not specifically assigned to a group are added to the **DEFAULT** AAA group. Policies can be set at both the user and group level but a user-level policy *overrides* a user's group-level policy.

Although AAA authentication is set by the *service* not the user, you can override this rule by configuring a user to authenticate at every login with **@<method>username**. The XSR checks if the *@-configured* user is configured before enabling the default authentication service. Refer to the next section to configure SSH or Telnet with AAA authentication.

Debugging of AAA data can be provided by the **debug aaa** command. Output is directed to the terminal where debugging information was most recently requested. Also, if multiple AAA debugs are activated, all data will be sent to the last used terminal requesting debugging. The sample AAA debug below displays a successful MSCHAP authentication using the local method:

```
Local::queue(test)
AAuthenticatePlugin::queue (alg == 0xf)
groupplugin Reply: Pool   = authpool
IRMauthorizeMsg::clientLogon [test]
```

Connecting Remotely via SSH or Telnet with AAA Service

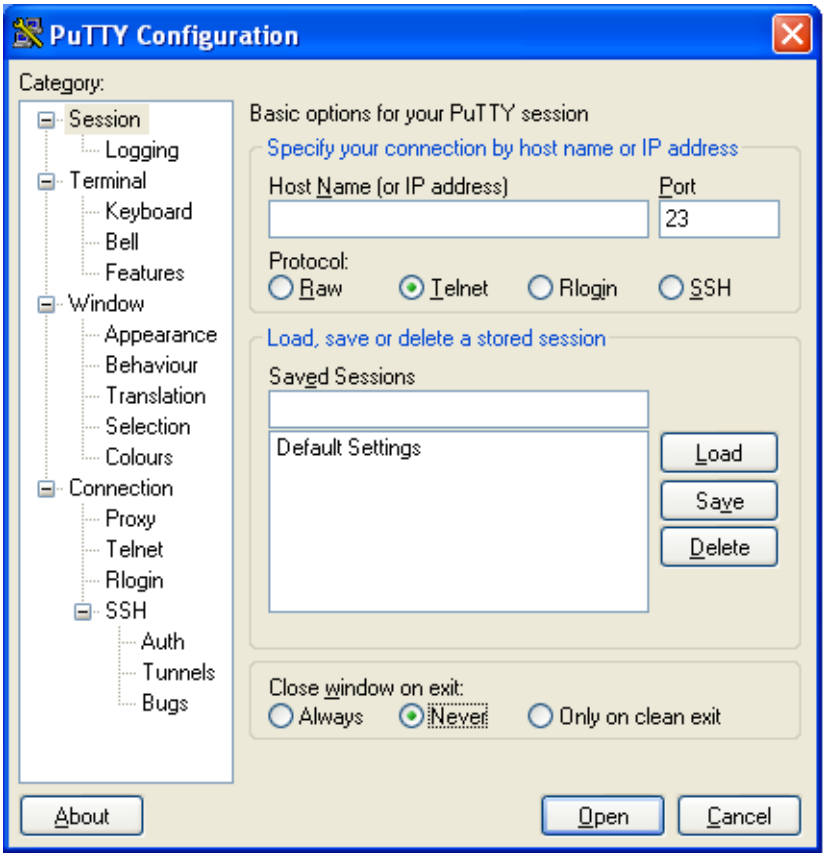
Perform the following commands to configure SSH or Telnet service:

1. On the CLI, enter **configure** to acquire Configuration mode.

2. Enter **`crypto key master generate`** to create a master key.
3. Enter **`crypto key dsa generate`** to create a host key pair on the XSR.

   When successful, this message will display: **`Keys are generated, new connections will use these keys for authentication`**
4. If you wish to connect using SSH, perform the following steps, otherwise skip to Step for Telnet configuration.
5. Install a freeware program such as PuTTY on your client device. If you load PuTTY, enable these options for maximum ease of use:
   - Click **Session**, *Close window on exit*, *Never*. See Figure 16-7.
   - Click **Terminal**, *Local echo*, *Force off*.
   - Click **Terminal**, *local line editing*, *Force off*.
   - Click **Connection**, *SSH, Don't allocate a pseudo-terminal.*

Figure 16-7 PuTTY Exit Option

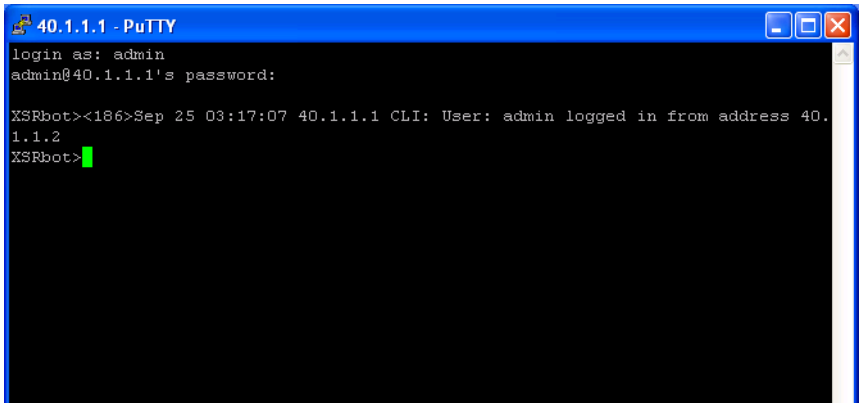


6. From the PuTTY **Session** window, select SSH (port changes to 22), enter the IP address of the configured XSR interface you wish to connect with, click **Load**, **Open** to begin an SSH session As this is the first time you are connecting to the server, the message shown in Figure 16-8 will appear. Click **NO** to start the SSH session.

Figure 16-8 PuTTY Alert Message

7. The SSH login screen will appear as shown in Figure 16-9. Login with **Admin** and no password unless you created both values earlier.

Figure 16-9 PuTTY Login Screen



8. Back on the CLI, enter **session-timeout ssh** <*15-35000*> to set the idle timeout period.
9. Optionally, if you want to tighten security on the XSR, enter **ip telnet server disable** to deactivate Telnet.
10. Enter **aaa user** <*name*> to create an authenticated user and acquire AAA user mode.
11. Enter **password** <*your password*> for the newly created user.
12. Enter **privilege 15** to set the highest privilege level for the user.
13. Enter **policy ssh** to enable SSH access for the user.
14. Enter **exit** to quit AAA user mode.
15. Enter **aaa client ssh** to enable AAA client SSH user authentication.

    If you also want to enable Telnet, enter **aaa client telnet**. The XSR is now ready to connect the remote login user.
16. Enter **session-timeout telnet** <*15-35000*> to set the idle timeout period.
17. Perform Step through Step .

18. Optionally, if you want to tighten security on the XSR, enter **ip ssh server disable** to deactivate SSH.
19. Enter **policy telnet** to enable Telnet access for the new user.
20. Enter **exit** to quit AAA user mode.
21. Enter **aaa client telnet** to permit the new user to employ Telnet.

    The XSR is now ready to connect remote login users. Remember to save your configuration after all edits.

Firewall Feature Set Overview

A firewall is defined generally as a set of related applications or a device dedicated to protect the enterprise network. Placed at any entry way to a corporation's private network, a firewall examines all packets arriving from the Internet and admits or bars traffic based upon its policies. A firewall may also control inside access to destinations on the Internet or interior resources.

Fundamentally, a firewall monitors and filters network traffic. Depending on your enterprise needs, you can set up a simple or more robust firewall. For instance, *application-level* filtering can be matched to source/destination IP addresses and port numbers for FTP, HTTP, NNTP, or Telnet; *protocol-level* filtering can be set on IP protocols such as OSPF, IGP or ICMP; and *stateful* filtering can be applied to a session's state.

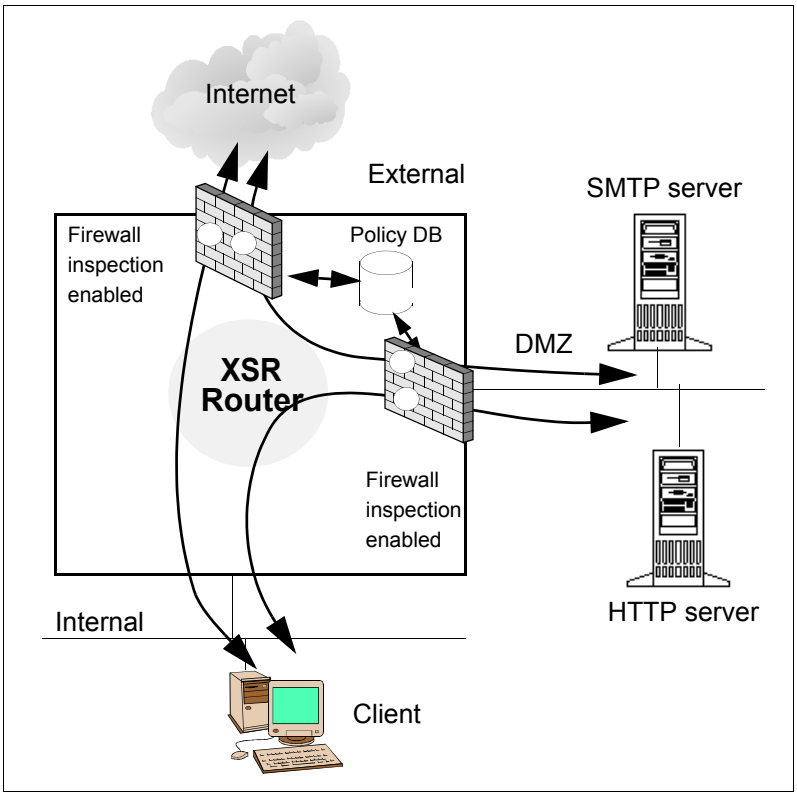
Reasons for Installing a Firewall

The rationale for installing a firewall can include the following:

- Provide a focal point for security decisions
- Segment networks into discrete security zones
- Enforce security policy between different security zones to protect proprietary information from falling into the wrong hands
- Enable users to safely connect to and conduct business over a public, untrusted network (Internet):
  - Restrict undesirable traffic that may otherwise flow between your internal hosts and the Internet
  - Protect internal networks from hostile and malicious attacks
- Log network activity
- Limit your exposure in case of a successful attack

Ideally, these network nodes should be checked daily for security holes, but since that is impractical, the next best course is to run a firewall to block all non-essential ports and cut the risk of attack. A firewall can be conceived as a virtual wall through which "holes" or ports are opened to allow permitted traffic through as shown in Figure 16-10 which illustrates a topology using the XSR firewall feature set.

Figure 16-10 XSR Firewall Topology



There are many possible network configurations for a firewall. The figure above shows a scenario with the firewall connected to the trusted network (internal) and servers that can be accessed externally (via the DMZ).

The XSR firewall feature set inspects packets coming in from open ports and either passes them on to the router or drops them based on policies defined in the policy database which is configured using the XSR's CLI.

In this example, the firewall acts as a shield for traffic coming in and out of the external and DMZ networks. The internal interface does *not* have nor does it need firewall inspection enabled because it is a trusted network.

While this flexibility is useful, it emphasizes the fact that the shield is only as effective as the intelligence of the policies. Functionally, the XSR's policy database defines the configuration and retains information about the sessions currently allowed through the firewall.

Types of Firewalls

Generally speaking, there are three types of firewalls: Access Control List (ACL) or Packet Filter, Application Level Gateway (ALG) or Proxy, and Stateful Inspection. Each of these firewall types operate at different layers of the TCP/IP network model, using different criteria to restrict traffic.

ACL and Packet Filter Firewalls

ACL and packet filter firewalls *statically* apply security policy to a packet's contents according to pre-configured rules you specify such as permitted or denied source and destination addresses

and port numbers. These firewalls are scalable, easy to implement and widely deployed for simple Network layer filtering, but they suffer the following disadvantages:

- Do not maintain states for an individual session nor track a session establishment protocol. Ports are usually always open or blocked
- Do not examine application data
- Do not work well with applications which open secondary data channels using embedded port information in the protocol - “difficult protocols” such as FTP and H.323 (video conferencing applications)
- Cannot detect protocol-level problems and attacks
- Less secure than stateful inspection or proxy firewalls

ALG and Proxy Firewalls

ALG or proxy firewalls filter packets at the top of the stack - Layer 5. They:

- Act as an agent (proxy) between IP client and server transactions. A proxy server often runs on dedicated, hardened operating systems with limited functionality, offering less of a chance to be compromised.
- Filter bad packets and bad contents to protect internal hosts incapable of protecting themselves against these attacks:
  - Bad packets (too long or too short)
  - Un-recognized commands (possible attack)
  - Legal but undesirable commands/operations (as set by policy)
  - Objectionable contents (content and URL filtering)
- Drop incoming/outgoing connections such as FTP, gopher, or Telnet applications at the proxy firewall first.
- Create two connections, one from the client to the firewall, the other from the firewall to the actual server. This generates a completely new packet which is sent to the actual server based on its data “read” of the incoming packet and correct implementation of the application's protocol. When the server replies, the proxy firewall again interprets and regenerates a new packet to send to the client.
- Build another layer of protection between interior hosts and the external world forcing a hacker to first break into the proxy server in order to launch attack on internal hosts.

But the above advantages of an application or proxy firewall are offset by the following weaknesses:

- *Higher overhead* - because it is usually implemented at the Application layer, additional processing is needed to transfer packets between the kernel and the proxy application.
- *Non-scalability* - support for a new protocol or a new feature of an existing protocol often lags by months or years.
- *Non-transparency* - proxy server users may discover the server bars an application, forcing users to find alternatives.

Stateful Inspection Firewalls

A stateful inspection firewall combines the aspects of other firewalls to filter packets at the network layer, determine whether session packets are legitimate and evaluate the payload of packets at the application layer. It allows a direct connection between client and host, alleviating the lack of transparency of ALGs. Also, it employs algorithms to recognize and process Layer 5 data rather than run application-specific proxies.

Additionally, a stateful inspection firewall provides:

- Inspection of a packet's communication and application state - acquired from past communication data throughout all layers. For example, an FTP session's PORT command can be saved to verify an incoming FTP data connection
- *Dynamic* filtering by opening ports only if the configured policy permits and when the application requires it
- The strongest security with the least processing overhead and fastest performance because stateful inspection is implemented in the kernel
- An Application Layer Gateway (ALG) to support applications which dynamically allocate ports for secondary data streams. ALGs apply stateful inspection to a *difficult* protocol such as FTP or H.323 by tracking control messages between client and server and learning the correct port number to open at the correct time.
- Smart service filtering and blocking. For example, it blocks un-authorized commands to an Email server, avoiding possible attacks
- More intelligent packet flooding attack prevention
- The capacity to search for and reject non-forming packets

XSR Firewall Feature Set Functionality

The XSR's firewall feature set provides the following functionality:

Stateful Firewall Inspection (SFI)

Stateful inspection is provided for TCP and UDP packets and monitoring of all incoming and outgoing TCP/UDP sessions. Incoming sessions must be *explicitly* allowed by configuring policy rules. For TCP, sessions are created and deleted by monitoring TCP SYN/ACK/FIN flags. Sessions for UDP are created based on packet flows with the first outbound UDP packet creating the session. Inactivity for an interval deletes the session.

Stateful inspection is available for *user-defined* and popular applications such as Bootp, FTP, AOL, et al. Enter the **`show ip firewall services`** command to display these and other supported applications as well as their associated source/destination port ranges and TCP/UDP affiliations.

Filtering non-TCP/UDP Packets

Non-TCP and UDP IP packets are controlled by a separate filtering mechanism and configured with a filter object. All non TCP and UDP packets are dropped by default. In order to pass a particular IP protocol packet through the firewall, you must configure a filter object for that protocol with the correct source and destination addresses.

Application Level Commands

A special action option - Command Level Security (CLS) - to filter inter-protocol actions within several protocols. The CLS examines the message type produced by the application being filtered and either passes or drops specific application commands. For example, FTP GETs can be allowed but PUTs denied. These protocols are supported:

- File Transfer Protocol (FTP)
- Simple Mail Transport Protocol (SMTP) and NNTP
- Hypertext Transfer Protocol (HTTP)

Application Level Gateway

Support is provided for FTP and H.323 version 2 protocols, and Remote Procedure Call (RPC) - based applications. The XSR ALG works with two types of RPCs: Sun's (and most Unix systems) and Microsoft's. The following pre-defined services are available for RPC and can be configured with the **`ip firewall service-group`** command:

- SunRPCTCP and SunRPCUDP
- MsftRPCTCP and MsftRPCUDP

RPC-based links are built in a client-server framework and RPC clients connect to RPC servers. A machine that hosts RPC server applications runs a daemon called the PortMapper using well-defined ports for TCP and UDP: Sun RPC uses 111, Microsoft uses 135. RPC operates as follows:

- RPC-based server applications register with the PortMapper, providing their listening port and application identifier. Because identifiers are issued by the IANA, they are unique.
- The client connects to the PortMapper and passes the application identifier along.
- In return, the PortMapper replies with the server's listening port.
- The client then initiates a connection to the server application using the listening port and the destination port.

The XSR's ALG inspects RPC messages between the client and PortMapper, storing the port numbers returned by the PortMapper in a cache. It then allows the client to connect to the ports that were returned. Once the connection is up, the ALG examines both TCP and UDP traffic.

The XSR ages out RPC cache entries if the client link does not occur or is idle bound the default period. You can reset the default with **`ip firewall`** {**`microsoft-rcp`** | **`sun-rpc`**} **`timeout`**.

Note: Once you permit RPC sessions between two hosts or networks, *all* TCP- or UDP-based RPC applications will be able to connect. Enterasys recommends that TCP-based RPC applications alone be allowed to pass through the Firewall since the session would be closed as soon as the connection terminates. RPC sessions are timed out using UDP and are therefore less secure than those using TCP.

The XSR limits the sum of stored UDP request cache entries which are used by other ALGs such as DHCP relay agent ALG. If no free UDP request cache entries exist then no more RPC-based connections are allowed until entries are freed. Assuming no other UDP packets pass through the Firewall, the maximum number of UDP request cache entries enforce the limit on number of RPC cache entries that the system can support.

For each RPC-based connection, two sessions are created. The first is a TCP or UDP session from the client to the PortMapper. The second is the application connection between the RPC client and the server. Both sessions are displayed by the **`show ip firewall sessions`** command and the RPC sessions can be identified by their destination ports of 111 or 135.

On Board URL Filtering

This features lets you block access to a list of Uniform Resource Locators (URLs) or limit access to certain approved sites. The XSR extracts the absolute URL from the Get and Host headers of the http Request packet sent by web browser, and matches that to a list of approved (white list), or banned (black list) URLs.

Importing URL Lists from an ASCII File

The XSR supports the import of URL lists from a user-specified ASCII text file using the **`ip firewall url-load-xxx name_of_url_xxx_list`** command where **`xxx`** stands for **`black-list`** or **`white-list`**. URL lists can be stored in either Flash or CFlash directories. Any of the following commands are acceptable:

```
XSR(config)#ip firewall url-load-black-list blacklists.txt
XSR(config)#ip firewall url-load-black-list flash:blacklists.txt
XSR(config)#ip firewall url-load-white-list cflash:whitelists.txt
```

Writing URL List Entries

When the **`ip firewall url-load-xxx`** command is run, the XSR immediately reloads the URL list database from the file. When you write URL entries for the file, observe the following:

- Entries are compared in a case-insensitive manner
- Up to 30 URL entries, each of which can be up to 63 characters long after leading and trailing white spaces (SPACEs, TABs) are removed from the input line. If a URL string has more than 63 characters, the XSR truncates it to 63 characters.
- If the URL file contains more than 30 entries, only the first 30 entries are loaded.

A URL list generally contains keywords of the URL you want to match. It can be as specific as a particular web page in a directory of an organization such as *www.w3.org/pub/WWW/theProject.htm*, or as general as a domain name such as *playboy.com*, or simply a file name such as *readme.eml*. The following are sample URLs:

- *arcadegamesonline.com*
- *games.yahoo.com*
- *siterankings.com/cgi-bin/casinos*
- *mail.bigmailbox.com/users/casinoranking.com*
- *top-lasvegas.com/en*
- *java.omnisportsbookmembers.com/javacasino*
- *216.91.118.35/ibet*
- *members.aol.com/winatcraps*
- *playboy.com*
- *readme.eml*

Enabling URL Filtering in Firewall Policy

The XSR firewall **`policy`** command lets you specify URL checking using the keywords **`URL-W`** or **`URL-B`**. *URL-B* instructs the XSR to compare the requested URL with a URL black list, so if a user tries to access a URL matching any black list entry, access will be blocked and the user presented with a blocked page similar to Figure 16-11 below. If the URL black list is not loaded, access is allowed.

Figure 16-11 Blocked Web Site Screen

You must include the re-direct URL in the white URL list when redirect URL is used with a white list, otherwise the XSR will enter an endless loop with the Web browser, performing re-direction to the same re-directed URL because it is not in the list.

URL-W tells the XSR to search the requested URL using the URL white list which restricts Web surfing to URLs matching the URL list. If a user tries to surf a Web site not on the URL list, he will be presented with blocked page similar to that shown above. If the XSR's optional *redirect URL* is configured (refer to the following section for details), then the user's Web client will be re-directed to fetch the configured redirect URL page. If a white URL list is not loaded, no http access is permitted for traffic set by the policy.

Caution: You must include the re-direct URL in the white URL list when redirect URL is used with a white list, otherwise the XSR will enter an endless loop with the Web browser, performing re-direction to the same re-directed URL because it is not in the list

URL filtering on black and white lists, respectively, can be configured as part of your firewall policy as follows:

```
XSR(config)#ip firewall policy Block_URL studentNet ANY_EXTERNAL HTTP URL-B allow
XSR(config)#ip firewall policy RestrictURL storeNet ANY_EXTERNAL HTTP URL-W allow
```

Configuring URL Redirection

You can configure a redirect URL with the **`ip firewall redirect URLredirect_url_string`** command. The *redirect_url_string* must uniquely identify the URL of the desired Web page to display and may total up to 63 characters. For example:

```
XSR(config)#ip firewall redirectURL www.ACME_INC.com/index.html
```

Note: The **`ip firewall redirectURL`** command takes effect immediately.

Denial of Service (DoS) Attack Protection

Security for internal hosts against a common set of DoS attacks when the firewall is enabled (globally and per interface). The firewall also uses the XSR's *HostDoS* feature to perform anti-spoofing - it enforces hostDos check-spoof for any firewall-enabled interface regardless of the hostDoS check-spoof setting. Check-spoofing is performed by validating the source IP address

against the routing table. If a packet is received from an interface with a source IP address that is not routable through this interface, it is considered spoofed and dropped.

A high priority log is generated when DoS attacks are detected. These DoS attacks are covered:

- *Anti-Spoofing* - In response to a spoof attack, the firewall drops all packets with a source address belonging to an internal network when received from an external interface. Packets from an internal interface with a source address not in the network will also be dropped.
- *ICMP Flood* - In response to ICMP echo requests received from different source addresses at a very high rate, the firewall sets a rate limit of ICMP echo requests processed per second.
- *Ping of Death* - In response, fragmented echo requests are dropped.
- *Smurf attack* - In response to a smurf attack where ICMP echo requests with the directed broadcast address is the destination and the source is any host, the firewall will filter echo requests to directed broadcasts or *all* directed broadcast packets.
- *SYN Flood* - In response to a continuous TCP open packets (SYN bit set) stream targeting an address, the firewall limits the number of half-open TCP links and set a max rate of TCP links.
- *Tear drop* - In response to receiving IP fragments that overlap, the firewall will track fragments received for every session, detect bad offsets and drop the entire packet (all fragments).
- *Christmas Tree* - When a TCP packet is received with all flags set, TCP packets with any two of the SYN, FIN or RST bits set are dropped.
- *LANd* - In response to receiving a TCP SYNC packet with the same source and destination address, the firewall will drop any packet with same source and destination address.

Alarm Logging

The XSR supports Console and Syslog logging and provides session usage data using the *allow-log/log* options. If you want to enable *persistent logging* which preserves logs after a system reboot, you must install a CompactFlash memory card in the XSR. Logs stored in Flash are purged during a system reboot unless the XSR senses the presence of CompactFlash.

Alarms

The XSR generates firewall alarms in the following categories:

- TCP and UDP packets
  - Permitted connect and disconnect
  - Blocked connects and disconnects
  - Blocked data packet
  - Individual packet logging per user configured firewall policy (by stipulating **`allow_log`** or **`log`**)
- IP option Permit or Deny logs
- Other Protocols Permit or Deny Logs
  - OSPF, ESP, RIP, GRE
  - ICMP
  - Broadcast, multicast
- Specific FTP, HTTP and SMTP requests logs

- Flooding attacks (TCP, UDP, ICMP) logs
- Firewall start and restart
- Failures (out of memory)

A sample Web access (port 80) *permit* alarm, which logs at level 4, displays:

```
FW: Permit: Port-2, Out TCP Con_Req, 10.10.10.10(1042) -> 192.168.1.200(80)
FW: TCP new session request. 10.10.10.10(1042) -> 192.168.1.200(80)
FW: Permit: Port-1, TCP Con_Est, 192.168.1.200(80) -> 10.10.10.10(1042)
FW: TCP connection closed 192.168.1.200(80) -> 10.10.10.10(1042)
```

A sample client open connection to the FTP server (port 21) alarm displays:

```
FW: Permit: Port-1, Out TCP Con_Req, 10.10.10.10(1056) -> 192.168.1.100(21)
FW: TCP new session request. 10.10.10.10(1056) -> 192.168.1.100(21)
FW: Permit: Port-1, TCP Con_Est, 192.168.1.100(21) -> 10.10.10.10(1056)
```

The IP addresses cited in firewall alarms are selected as follows:

- If a syslog server is configured, alarms will contain the XSR IP address that is used to contact the syslog server.
- If no syslog server is configured, alarms will contain the IP address of the first circuit. FE1 will be checked first, then FE2, then any WAN interface until an IP address is obtained.
- If no interfaces have been configured with an IP address, the hostname will be used.

Authentication

AAA services provide secure access across the firewall delineated by several levels: *user*, *client* and *session*. This release supports only client authentication which verifies a remote host based on its IP address. All firewall policy rules that specify *allow-auth* as the action check the source IP address of the received packet in the auth cache before approving the session.

For the remote user, the XSR requires manual sign-on using Telnet to default port 3000 or another configured port. The user is prompted for a user name and password, and those credentials are checked with either an authenticating server (RADIUS) or local database on the XSR (see Figure 16-12).

Figure 16-12 Authentication Process

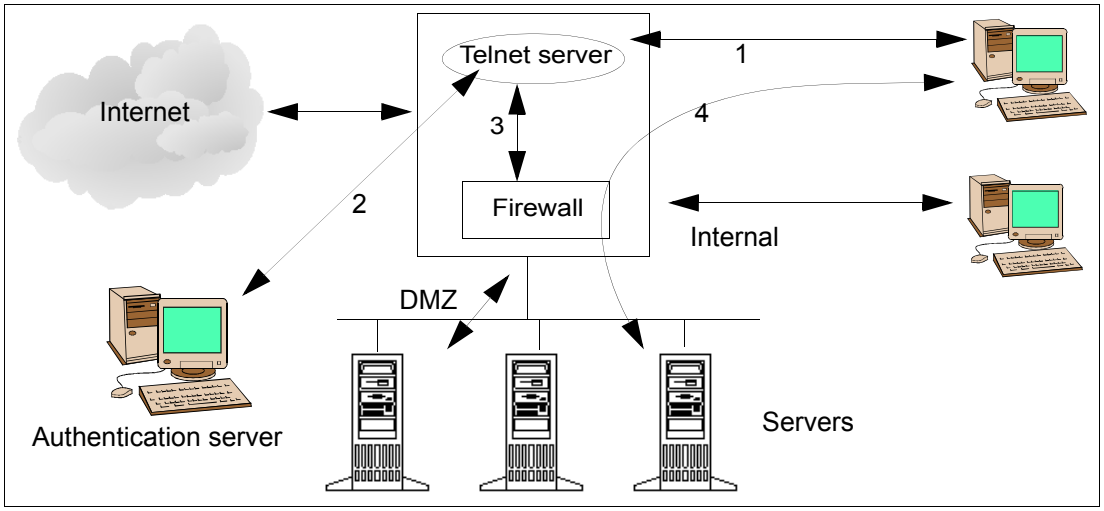


Figure 16-12 illustrates the process by which a user accesses a server after authentication by the XSR firewall, as explained below:

1. A user Telnets to the firewall presenting a name and password.
2. The XSR's AAA functionality talks to an authentication server or consults a local database based on the user's credentials.
3. If authentication is successful, AAA informs the firewall engine of the user's source IP address and an authentication entry is created within the firewall engine.
4. Policy rules specified for the firewall allow the user access to a server after consultation with the firewall engine's authentication cache.

   Authentication failures are tracked using logs or traps and entries time out after an inactive period. If authentication fails, all packets that match policy rules with *allow-auth* for that source IP are dropped.

Firewall and NAT

On *outgoing* packets, stateful inspection is done *before* NAT because NAT modifies the source address of all packets to that of the XSR and policy rules are defined with respect to internal and external addresses. On *incoming* packets, NAT is preformed *before* firewall inspection.

Beginning with Release 7.0, the XSR supports IPSec NAT traversal according to *draft-ietf-ipsec-nat-t-ike-02*. The XSR sends IKE messages from UDP port 4500 when 1), a NAT is present between IKE peers and 2), the peer has implemented *draft-ietf-ipsec-nat-t-ike-02*. So, you need to allow traffic to UDP port 4500 to pass through the firewall if you want to allow users to build IPSec SAs that traverse the firewall. Refer to "XSR with Firewall and VPN" on page 16-27 for a sample configuration.

Firewall and VPN

VPN tunnels are implemented as virtual interfaces that "sit" on physical interfaces. Stateful inspection is applied *before* encryption and encapsulation on *outgoing* packets and *after* de-capsulation and decryption on *incoming* packets.

ACLs and Firewall

Access Control Lists are available as a basic filter on a per interface basis to pass or drop packets going in or out of a port. In the outbound direction, a packet is subjected to firewall inspection before filtering by an ACL. Inbound, a packet is filtered by an ACL then the firewall.

Note: Be aware that if the firewall is enabled on an interface, ACLs should not be used on that interface so that all checks can be performed in one place.

Dynamic Reconfiguration

The XSR lets you apply new or remove old policies without restarting the firewall code. Dynamic reconfiguration is accomplished by checking the current firewall stateagainst newly configured rules. Sessions which do not satisfy these rules are removed leaving other sessions intact.

Firewall CLI Commands

The XSR provides configuration objects which, used in policy rules, can be specified at the CLI. These and other firewall commands are, as follows:

- *Network* - Identifies a network or host. A network with a subnet address or a host with an address and 32-bit mask is specified with **`ip firewall network`**. The command also configures a network or host residing on the trusted/internal or un-trusted/ external network.

Caution: Use care not to overlap internal and external address ranges since internal ranges take *precedence* over external ranges, and if an address exists in both ranges, the internal address will be considered for policy matching. In certain situations this may cause unexpected results, specifically if the other address in a policy is also internal and you expect a match for a policy rule to use that internal address against a wildcard such as *ANY_EXTERNAL* as the second address. This rule will not be matched if the address you expect to be part of *ANY_EXTERNAL* is also defined in an internal address range.

  You can configure a network object from an internal address to any address on the Internet as follows:

```
XSR(config)#ip firewall network Any_address 1.0.0.1 255.255.255.254 external
```

  or

```
XSR(config)#ip firewall network Internet 0.0.0.0 mask 0.0.0.0 external
```

- *Network group* - Defines a group of network objects - you can group up to ten for simpler configuration referenced by a single name with **`ip firewall network-group`**. The intrinsic, pre-defined *ANY_EXTERNAL* and *ANY_INTERNAL* groups are maintained automatically by the firewall as long as you have defined at least one other internal or external group.
- *Service* - Specifies an application's protocol and source/destination ports with **`ip firewall service.`** Packets with the source port in the specified range will match this service as will packets with the destination port. TCP and UDP protocols are supported. Intrinsic services for all ports are ANY_TCP for TCP port ranges, and ANY_UDP for UDP port ranges.
- *Service group* - Aggregates a number of service objects with **`ip firewall service-group`**. Typically, the service-group name is the specified application. You can group up to 10 objects.
- *Policy* - Defines which applications can traverse the firewall and in which direction with **`ip firewall policy`**. Packets which match addresses and service are processed by these actions: *allow*, *allow-auth*, *reject*, *log*, *reject*, *cls*, etc. Configuration must observe these rules:
  - *Any address combination* - You can define network addresses as follows: external to internal, internal to external, and internal to internal. External to external is *not* supported.
  - *Rule order* - Earlier entered rules take precedence.
  - *Deny All for Unicast packets* - The XSR firewall observes a DENY ALL default policy. So, unless explicitly allowed, all packets are dropped both ways.
  - You should set a rule at the end of your configuration to handle default behavior in a specific direction. For example, in order to allow all packets from internal to external except for Telnet and FTP packets, rules for these applications must be defined first.

    Then you must define a rule allowing access to ANY_INTERNAL source and ANY_EXTERNAL destination for any service. These values are case-sensitive.

  - *Non-Unicast packet handling* - Packets with broadcast or multicast destination addresses are not allowed to pass in either direction - they must be allowed explicitly.
  - This rule makes it easy to deny access to IP broadcast/multicast packets through the firewall but to allow access, you must issue the **ip firewall ip-broadcast** or **ip firewall ip-multicast** commands as well as set policy.
  - *IP Packets with options* - Packets with options are dropped either way by default. You must *permit* options explicitly either way.

- *Naming conventions* - Any firewall object name must use these alpha-numeric characters only: A - Z (upper or lower case), 0 - 9, - (dash), or _ (underscore). Also, all firewall object names are case-sensitive.
- *TCP/UDP/ICMP Filter* - Filters TCP, UDP, or ICMP packets and assigns an idle session timeout for their inspection with **ip firewall tcp, ip firewall udp,** and **ip firewall icmp.**
- *Non-TCP/UDP Filter* - Defines packet filtering of non-TCP and UDP protocols with **ip firewall filter**. Because these packets are dropped by default, to allow any other IP protocol packet to pass through the firewall you must specify a filter object with the correct source/destination IP address and IP protocol ID.
- *Java and ActiveX* - Allows HTML pages with Java and ActiveX content through the firewall with the **ip firewall java** and **ip firewall activex** commands. Options include *allowing* from all or *selected* IP addresses, or *denying* from any IP address.
- *System Filter* - Specifies Interface mode filtering with the **ip firewall ip-options** (for loose or strict routing through the Internet, trace routes or record time stamps), **ip-broadcast** (for DHCP, e.g.), and **ip-multicast** (for routing) commands.
- *Enable/Disable* - Turns firewall on or off with **ip firewall** {**enable** | **disable**}. The firewall is set per interface or globally and is *disabled* on all interfaces, by default. If the firewall is globally disabled, a local enable is ignored and if globally enabled, all interfaces are "on" unless you explicitly disable each port. **Enable** displays in **running-config**, but not **disable**.
- *Load* - Installs the completed firewall configuration in the XSR's inspection engine with **ip firewall load**. This command avoids conflicts with existing sessions by clearing them. But, before doing so you can perform a *trial load* to verify settings or configure incrementally and check for errors between loads. You can view modified settings before loading with **show ip firewall config**. Also, the *delay load* option schedules a load and **show ip firewall general** displays an outstanding delay and when it will run. Be aware that you must copy the **running-config** to **startup-config** file to save any changes. Commands entered at the CLI are not in the configuration until the **load** command is invoked, so if you omit a load and save the **running-** to **startup-config** file, the commands you entered will not display. Several other **show** commands display various objects that are in effect, that is, those that have been loaded (refer to the following bullet).

Caution: Performing a *load* requires that you re-establish all TCP connections including Telnet sessions and PKI links to the Certificate Authority. Also, firewall configuration changes are blocked during a *load delay*.

- *Display Commands* - A host of firewall **show** commands are available to display firewall attributes for each firewall configuration command. Also, **show ip firewall config** displays the as yet un-committed configuration, **show ip firewall sessions** displays dynamic TCP, UDP and ICMP session data, and **show ip firewall general** displays summary system firewall statistics such as the status of the firewall, protected and unprotected interfaces, sessions counters, and number of DoS attacks.

- *Event Logging* - Defines the event threshold for firewall values logged to the Console or Syslog with **`ip firewall logging`**. You can set eight severity levels ranging from 0 for emergency alarms down to 7 which *cumulatively* logs all firewall messages through 0, as follows:
  - Level 0: **Emergency**
  - Level 1: **Alert**
  - Level 2: **Critical** - alarms such as *failure to allocate memory during initialization* are logged if system logging is enabled and firewall logging is set to level 2 or higher
  - Level 3: **Error** - *abnormal* and *deny* alarms are logged if system logging is set at MEDIUM or HIGH and firewall logging is level 3 or higher
  - Level 4: **Warning** - *normal* and *permit* alarms are logged if system logging is set at LOW and firewall logging is level 4 or higher
  - Level 5: **Notice**
  - Level 6: **Information**
  - Level 7: **Debug**

  You can generate fewer firewall alarms by setting a *low* logging level with the system **`logging`** command.

  To further minimize alarms and overhead for the XSR, configure the firewall alarm level to 0 with the **`ip firewall logging`** command. This value is independent of the XSR logging priority, and taking this action avoids generating firewall alarms that are later dropped anyway by the XSR's system alarm logging mechanism.
- *Authentication* - Defines firewall authentication with *idle timeout* and *port range* values with **`ip firewall auth`**. Also, the **`ip firewall policy`** command applies authentication rules on a group basis. Authentication entries for users are configured using the AAA commands including **`aaa user`** and **`password`**, **`aaa group`**, **`aaa policy`**, and **`aaa client`**. When configuring the firewall policy *group_name*, be sure it matches the *AAA group name*. When entering the **`telnet <address> <port-number>`** command, the screen shown in Figure 16-13 appears. Be aware that configured usernames and passwords must be less than 32 characters and can include non-alphanumeric characters.

Figure 16-13 Sample Telnet Screen

```
Please provide username and password.
Username: clarkkent
Password:******
Authenticated.


XSR>,186>Mar 4 22:56:20 10.10.10.20 CLI: User: clarkkent
logged in from address 10.10.10.10.
XSR>
```

Be aware that a Telnet session left idle for more than one minute is terminated by default. Set the idle timeout with **`session-timeout`**.

Firewall Limitations

Consider the following caveats regarding firewall operations:

- *Gating Rules* - Internal XSR gating rules, which order traffic filtering, are stored in a temporary file in Flash. Because one gating rule exists for each network source/destination expansion, a potentially enormous number of rules can be generated by just a single firewall policy. For example, when a large network that has an *ANY_INTERNAL* group with 200 network addresses is used as the source address, and another group of 10 network addresses is used as the destination address, 2000 gating rules are defined for the policy. Be aware that each bidirectional policy produces two gating rules per address pair.

  Because gating rules must be unique, those policies which create multiple gating rules when source or destination addresses are network group objects will have a gating rule *extension* appended to the actual policy name that was entered in the CLI command. Firewall log messages specifying the policy name will display the following, for example:
  `Log: TCP, Policy P_intExtFtp_0-2, 10.10.10.100(1033)-> 20.20.20.100(21)`
  where **`P-intExtFtp`** is the CLI policy name and **`_0-2`** is the gating rule extension.

- *Memory Limits* - The number of permitted firewall objects are constrained by the size of installed RAM in the XSR as follows. Be aware that these limits can be mitigated through the use of memory management. Refer to "Memory Management" on page 2-37 for more details.

- *Session Timeouts* - Idle timeout defaults for the three firewall session types are enforced as follows:

  – *TCP* idle timeout sessions: 3600 seconds

  – *UDP* and *ICMP* idle timeout sessions: 60 seconds

- *Pre-defined Services* - Some pre-defined firewall services may not work with applications which use dynamic source ports greater than 1024. As a work around, specify a *user- defined* service to cover a wider source port range.

- *SNMP* - SNMP is not supported for configuration, data and traps.

- *ACL/Firewall* - Access Control Lists (ACLs) are supported for security on a per interface basis. Interface ACLs allow or drop packets traversing the port in a specified direction (in or out). Heading *outbound*, packets face firewall inspection before ACLs. Going *inbound*, packets first face ACLs, followed by the firewall. So, if the firewall is enabled on an interface, we recommend ACLs not be used on that port so that all checks can be performed in one place.

- *Firewall/NAT* - On *outgoing* packets, *stateful inspection* is performed before NAT. This is due to the fact that NAT modifies the source address of all packets to the XSR's address and policy rules are defined with respect to internal and external addresses. On *incoming* packets, *NAT* is performed before firewall inspection. Firewall rules are written using the actual addresses on the internal (even if they are private IP addresses) and exterior networks, independent of whether NAT is enabled on the interface.

- *Firewall/VPN* - VPN tunnels are implemented as virtual interfaces that *sit* on physical interfaces. *Stateful inspection* is applied before encryption and encapsulation for *outgoing* packets and after de-encapsulation and decryption for *incoming* packets.

- *Firewall and Un-numbered Interface* - The firewall does not interoperate with interface IP addresses - it is concerned with IP addresses in packets that traverse an interface. So, if the firewall is enabled on an un-numbered interface, it performs similarly as on a numbered one.

- *Firewall/VRRP* - The firewall does not interoperate with the Virtual Router Redundancy Protocol (VRRP). That is, if a switch-over occurs, the firewall sessions and authentication

cache will not automatically switch over. If the firewall is enabled on a slave router, then all sessions would have to be re-established. You would have to re-authenticate users for access to authentication-protected servers.

- *Load Sharing* - If two or more firewall-enabled XSRs are linked, load sharing is not supported. Each XSR would act as a discrete firewall and monitor sessions that pass through it.
- *Secondary IP Address/Firewall* - The firewall does not interoperate with interface IP addresses, so, a secondary interface address has no affect on firewall operations. Configure network objects for the secondary address just as you would any primary IP address.
- *Firewall Authentication over VPN* - Firewall authentication is not supported over VPN tunnels.

Pre-configuring the Firewall

We recommend you consider the following suggestions to set up the firewall:

- Establish a security plan by:
  - Examining your network topology
  - Determining exactly what resources you want to protect
  - Deciding where on the network to enable the firewall and plan on writing a Telnet or SSH policy for remote administration if you are configuring an XSR located in the field
  - Making a list of internal addresses
  - Forming an inventory of desirable applications the firewall will allow between protected and external networks
- Look up official port numbers of well-known applications at: http://www.iana.org/assignments/protocol-numbers

  The **`show ip firewall session`** command also lists these numbers.
- Refer to "Firewall Limitations" on page 16-22 before configuration

Steps to Configure the Firewall

Follow the procedure below to configure the firewall:

- Specify the network objects
- Specify network-group, service and service group objects
- Write TCP/UDP policies. The order is important and objects and names are case-sensitive
- Specify filters for other protocols (ICMP, OSPF, ESP, etc.)
- Set miscellaneous parameters such as:
  - TCP, UDP or ICMP session timeouts
  - Logging event-levels 0-7
  - Authentication service for users
  - Java and ActiveX filtering
  - IP options filtering on the interface such as time-stamps, route recording, and loose or strict routing through the Internet

  - Multicast or broadcast filtering for routing and communications protocol filtering
- Perform a trial or delayed load to check for configuration errors
- Load the configuration in the firewall engine
- Enable or disable the firewall:
  - System wide, or on
  - Individual interfaces or sub-interfaces
- After installing the firewall, check blocked traffic in event logging for missed application rules
- Use port scanning tools to ensure policies are properly implemented

Configuration Examples

The following sample configurations describe step-by-step how to set up these firewall scenarios:

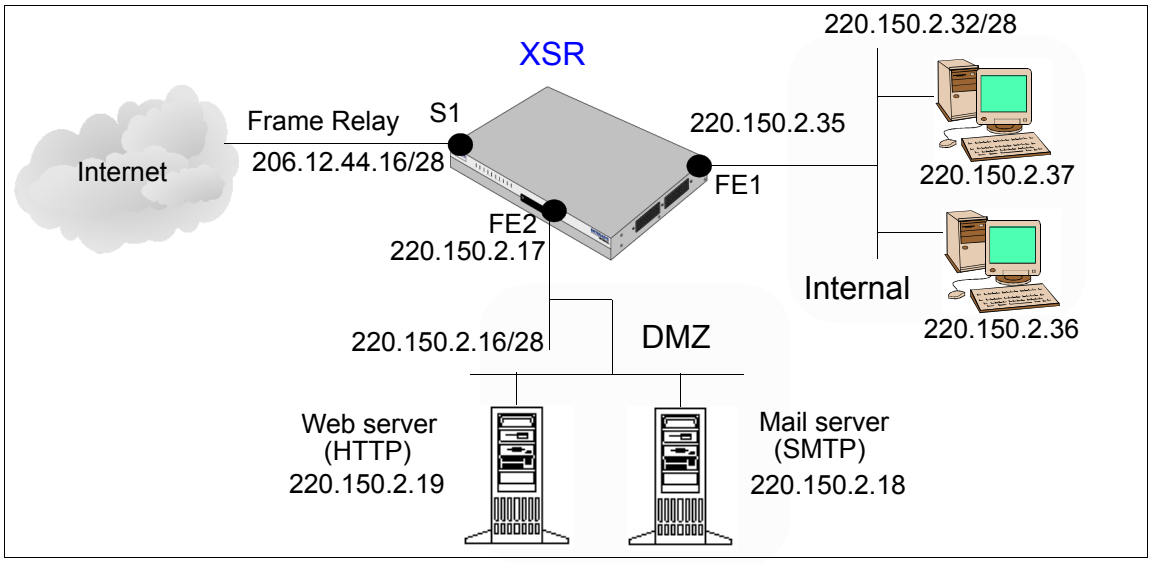
- XSR with firewall on page 16-24
- XSR with firewall, PPPoE, and DHCP on page 16-26
- XSR with firewall and VPN on page 16-27
- Firewall configuration for VRRP on page 16-33.
- Firewall configuration for RADIUS authentication on page 16-33.
- Simple security on page 16-34.
- RPC configuration on page 16-35.

XSR with Firewall

In this scenario, the XSR acts as a router connecting a branch office to the Internet, as illustrated in Figure 16-14. The branch office has two servers (Web and Mail) accessible from the external world and an internal network of hosts which are protected from the external world by the firewall. The Web and Mail servers are part of the DMZ and considered internal by the XSR. Note that some commands have been abbreviated.

This configuration, illustrated in Figure 16-14, provides *private* and *dmz* networks with unlimited access between each other while protecting traffic to and from the external interface only - this is done by enabling the firewall on the external interface *only*. No policies are defined for traffic between *private* and *dmz* networks. Also, all Java and ActiveX pages, IP options, IP broadcast and multicast packets are banned.

Figure 16-14 XSR with Firewall Topology



Begin by configuring network objects for *private*, *dmz* and *Mgmt* networks:

```
XSR(config)#ip firewall network dmz 220.150.2.16 mask 255.255.255.240 internal
XSR(config)#ip firewall network private 220.150.2.32 mask 255.255.255.240
internal
XSR(config)#ip firewall network Mgmt 220.150.2.35 mask 255.255.255.255 internal
```

Log only critical events:

```
XSR(config)#ip firewall logging event-threshold 2
```

Allow ICMP traffic to pass between *private*, *dmz* and *EXTERNAL* networks:

```
XSR(config)#ip firewall filter okICMP private ANY_EXTERNAL protocol-id 1
XSR(config)#ip firewall filter ICMP1 dmz ANY_EXTERNAL protocol-id 1
XSR(config)#ip firewall filter ICMP2 ANY_EXTERNAL dmz protocol-id 1
```

Set policies between the *dmz*, *external* and *Mgmt* networks. Note that policy objects and names are *case-sensitive* and you must cite network names *exactly*:

```
XSR(config)#ip firewall policy exttodmzhttp ANY_EXTERNAL dmz HTTP allow
bidirectional
XSR(config)#ip firewall policy exttodmzsmtp ANY_EXTERNAL dmz SMTP allow
bidirectional
XSR(config)#ip firewall policy TelnetSESS private Mgmt Telnet allow bidirectional
```

Set a policy to allow any traffic to pass from *private* to *EXTERNAL* networks:

```
XSR(config)#ip firewall policy prvtoextprivate ANY_INTERNAL ANY_EXTERNAL allow
after
```

Trial load the completed configuration into the firewall engine, and if successful, load the configuration:

```
XSR(config)#ip firewall load trial
XSR(config)#ip firewall load
```

Complete LAN and WAN interface configuration:

```
XSR(config-if<F1>)#interface fastethernet 1
XSR(config-if<F1>)#ip address 220.150.2.35 255.255.255.0
XSR(config-if<F1>)#no shutdown
```

```
XSR(config)#interface fastethernet 2
XSR(config-if<F2>)#ip address 220.150.2.17 255.255.255.0
XSR(config-if<F1>)#no shutdown

XSR(config)#interface serial 1/0:0
XSR(config-if<S1/0:0>)#ip address 206.12.44.16/24
XSR(config-if<S1/0:0>)#no shutdown
```

Globally enable the firewall. Even though you have configured and loaded the firewall, only invoking the following command "turns on" the firewall. Once enabled, if you are remotely connected, the firewall will close your session. Simply login again.

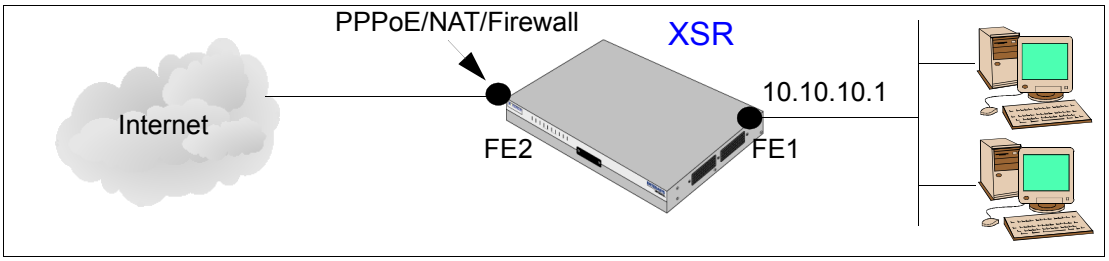
```
XSR(config)#ip firewall enable
```

XSR with Firewall, PPPoE and DHCP

In this scenario, shown in Figure 16-15, the branch office uses a private address for its hosts. Access to the external networks configured with PPPoE DSL service on the FastEthernet 2 interface/sub-interface and DHCP set on the FastEthernet 1 interface. A global IP address is available for a Web server and a static NAT entry is set for them. Also, all Java and ActiveX pages, IP options, IP broadcast and multicast packets are banned.

Policies apply to the private addresses as outbound filtering is performed *before* NAT and inbound filtering *after* NAT. This is key because the firewall is oblivious to the global IP address used. Some commands are abbreviated.

Figure 16-15 XSR Firewall with PPPoE (DSL) and DHCP



Configure the LAN interfaces, enable DHCP, and disable the firewall on both LAN ports:

```
XSR(config)#interface FastEthernet1
XSR(config-if<F1>)#ip address 10.10.10.1 255.255.255.0
XSR(config-if<F1>)#ip dhcp server
XSR(config-if<F1>)#ip firewall disable
XSR(config-if<F1>)#no shutdown

XSR(config)#interface FastEthernet2
XSR(config-if<F2>)#ip firewall disable
XSR(config-if<F2>)#no shutdown
```

Enable the PPPoE interface with a negotiable IP address, adjusted MTU packet size, PAP authentication, and NAT enabled:

```
XSR(config-if<F2>)#interface FastEthernet 2.1
XSR(config-if)#encapsulate ppp
```

```
XSR(config-if)#ip address negotiated
XSR(config-if)#ip mtu 1492
XSR(config-if)#ip nat source assigned overload
XSR(config-if)#ppp pap sent-username b1jsSW23 "password is not displayed"
XSR(config-if)#no shutdown
```

Attach a static route to the PPPoE interface and add a local IP pool:

```
XSR(config)#ip route 0.0.0.0 0.0.0.0 FastEthernet2.1
XSR(config)#ip local pool myDhcpPool 10.10.10.0 255.255.255.0
```

Specify network objects including *Mgmt* and *Ten* for SSH and DHCP service:

```
XSR(config)#ip firewall network INT_NETS 10.10.10.0 mask 10.10.10.255 internal
XSR(config)#ip firewall network MY_EXT 1.0.0.0 255.255.255.254 external
XSR(config)#ip firewall network Mgmt 10.10.10.1 mask 255.255.255.255 internal
XSR(config)#Ip firewall network Ten 10.1.0.0 mask 255.255.0.0 internal
```

Set the policies and filters allowing *Web, DNS, FTP, SSL,* and *ICMP* traffic between ANY_INTERNAL and ANY_EXTERNAL networks. Also write a policy for DHCP and SSH access to the XSR. Be sure to install an SSHv2 client on your connecting PC. Note that policy objects and names are case-sensitive and you must cite network and protocol names *exactly*:

```
XSR(config)#ip firewall policy P_intExtHttp ANY_INTERNAL ANY_EXTERNAL WWW allow
XSR(config)#ip firewall policy P_intExtDns ANY_INTERNAL ANY_EXTERNAL DNSUDP allow
XSR(config)#ip firewall policy P_intExtFtp ANY_INTERNAL ANY_EXTERNAL FTP allow
XSR(config)#ip firewall policy P_intExtHttps ANY_INTERNAL ANY_EXTERNAL SSL allow
XSR(config)#ip firewall policy adminSSH ANY_INTERNAL Mgmt SSH allow bidirectional
XSR(config)#ip firewall policy allowDHCP Ten Ten Bootp allow bidirectional
XSR(config)#ip firewall filter F_ECHO_RESP ANY_EXTERNAL ANY_INTERNAL protocol-
keyword ICMP 0
XSR(config)#ip firewall filter F_ECHO_REQ ANY_INTERNAL ANY_EXTERNAL protocol-
keyword ICMP 8
```

Trial load the completed configuration into the firewall engine, and if successful, load the configuration:

```
XSR(config)#ip firewall load trial
XSR(config)#ip firewall load
```

Configure the DHCP pool, DNS server and related settings:

```
XSR(config)#ip dhcp pool myDhcpPool
XSR(config)#default-router 10.10.10.1
XSR(config)#dns-server 209.226.175.223
XSR(config)#domain-name BT_basement
XSR(config)#lease 1 3 15
```

Globally enable the firewall. Even though you have configured and loaded the firewall, only invoking the following command "turns on" the firewall. Once enabled, if you are remotely connected, the firewall will close your session. Simply login again.

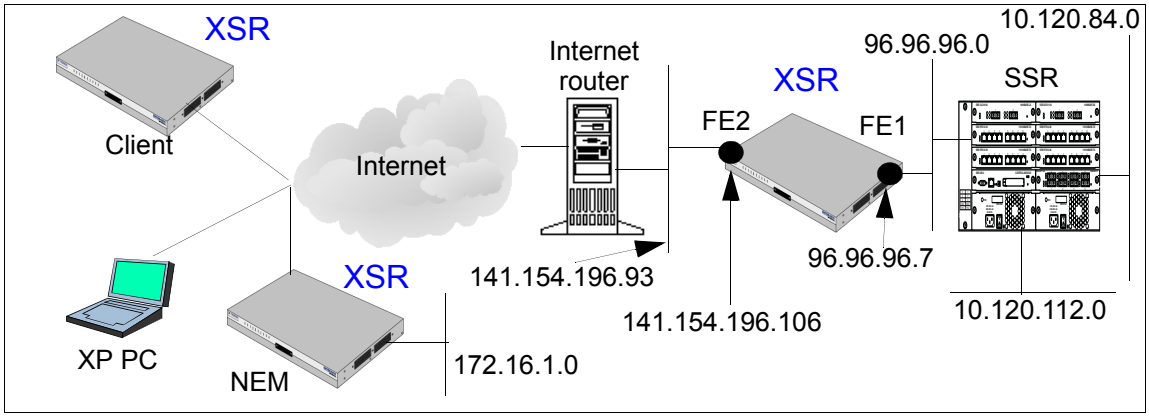
```
XSR(config)#ip firewall enable
```

XSR with Firewall and VPN

In this scenario, as illustrated in Figure 16-16, a head-end VPN gateway is configured to perform the following:

- Terminate Network Extension Mode (NEM) and Client mode tunnels
- Terminate remote access L2TP/IPSec tunnels
- Terminate PPTP remote access tunnels
- Firewall inspection on the public VPN interface (the crypto map interface)
- Firewall inspection on the trusted VPN interface (the connection to the corporate network)
- Enable NAT Traversal on the firewall
- OSPF routing with the next hop corporate router on the trusted VPN interface
- DF bit clear on the public VPN interface to handle large non-fragmentable IP frames
- OSPF routing over the multi-point VPN interface for other site-to-site tunnels
- Assign the first IP address of the pool to the multi-point VPN interface

Figure 16-16 XSR Firewall, VPN and OSPF Topology



Begin by setting the XSR system time via SNTP. This configuration is critical for XSRs which use time-sensitive certificates.

```
XSR(config)#sntp-client server 10.120.84.3
XSR(config)#sntp-client poll-interval 60
```

Add four ACLs to permit IP pool, L2TP and NEM traffic:

```
XSR(config)#access-list 110 permit ip any 10.120.70.0 0.0.0.255
XSR(config)#access-list 120 permit udp any any eq 1701
XSR(config)#access-list 140 permit ip any 172.16.1.0 0.0.0.255
XSR(config)#access-list 150 permit ip any 192.168.111.0 0.0.0.255
```

Define IKE Phase I security parameters with the following two policies:

```
XSR(config)#crypto isakmp proposal xp-soho
XSR(config-isakmp)#hash md5
XSR(config-isakmp)#lifetime 50000
XSR(config)#crypto isakmp proposal p2p
XSR(config-isakmp)#authentication pre-share
XSR(config-isakmp)#lifetime 50000
```

Configure IKE policy for the remote peer:

```
XSR(config)#crypto isakmp peer 0.0.0.0 0.0.0.0
```

```
XSR(config-isakmp-peer)#proposal xp soho p2p
XSR(config-isakmp-peer)#config-mode gateway
XSR(config-isakmp-peer)#nat-traversal automatic
```

Configure the following IPSec SAs:

```
XSR(config)#crypto ipsec transform-set esp-3des-md5 esp-3des esp-md5-hmac
XSR(cfg-crypto-tran)no set security-association lifetime kilobytes

XSR(config)#crypto ipsec transform-set esp-3des-sha esp-3des esp-sha-hmac
XSR(cfg-crypto-tran)set security-association lifetime kilobytes 10000
```

Configure the following four crypto maps to match ACLs 150, 140, 120, and 110:

```
XSR(config)#crypto map test 50
XSR(config-crypto-m)#set transform-set esp-3des-sha
XSR(config-crypto-m)#match address 150

XSR(config)#crypto map test 40
XSR(config-crypto-m)#set transform-set esp-3des-sha
XSR(config-crypto-m)#match address 140

XSR(config)#crypto map test 20
XSR(config-crypto-m)#set transform-set esp-3des-md5
XSR(config-crypto-m)#match address 120
XSR(config-crypto-m)#mode transport
XSR(config-crypto-m)#set security-association level per-host

XSR(config)#crypto map test 10
XSR(config-crypto-m)#set transform-set esp-3des-sha
XSR(config-crypto-m)#match address 110
```

Configure FastEthernet interface 1 to permit multicast packets in and out:

```
XSR(config)#interface FastEthernet1
XSR(config-ifF1>)#ip address 96.96.96.7 255.255.255.0
XSR(config-ifF1>)#ip firewall ip-multicast in
XSR(config-ifF1>)#ip firewall ip-multicast out
XSR(config-ifF1>)#no shutdown
```

Configure FastEthernet interface 2 with the attached crypto map *test*:

```
XSR(config)#interface FastEthernet2
XSR(config-ifF2>)#crypto map test
XSR(config-ifF2>)#ip address 141.154.196.106 255.255.255.192
XSR(config-ifF2>)#no shutdown
```

Configure the VPN virtual interface as a terminating tunnel server with IP multicast redirection back to the gateway, add an OSPF network with cost and disable the firewall:

```
XSR(config)#interface Vpn1 multi-point
XSR(config-int-vpn)#ip multicast-redirect tunnel-endpoint
XSR(config-int-vpn)#ip address 10.120.70.1 255.255.255.0
XSR(config-int-vpn)#ip firewall disable
XSR(config-int-vpn)#ip ospf priority 10
XSR(config-int-vpn)#ip ospf network nbma
```

Add a default route to the next hop Internet gateway:

```
XSR(config)#ip route 0.0.0.0 0.0.0.0 141.154.196.93
```

Define an IP pool for distribution of tunnel addresses to all client types:

```
XSR(config)#ip local pool test 10.120.70.0 255.255.255.0
```

Create hosts to resolve hostnames for the certificate servers for CRL retrieval:

```
XSR(config)#ip host parentca 141.154.196.89
XSR(config)#ip host childca2 141.154.196.81
XSR(config)#ip host childca1 141.154.196.83
```

Clear the DF bit globally:

```
XSR(config)#crypto ipsec df-bit clear
```

Enable the OSPF engine, VPN and FastEthernet 1 interfaces for routing:

```
XSR(config)#router ospf 1
XSR(config-router)#network 10.120.70.0 0.0.0.255 area 5.5.5.5
XSR(config-router)#network 96.96.96.0 0.0.0.255 area 5.5.5.5
```

Create a group for NEM and Client mode users:

```
XSR(config)#aaa group sohoclient
XSR(aaa-group)#dns server primary 10.120.112.220
XSR(aaa-group)#dns server secondary 0.0.0.0
XSR(aaa-group)#wins server primary 10.120.112.220
XSR(aaa-group)#wins server secondary 0.0.0.0
XSR(aaa-group)#ip pool test
XSR(aaa-group)#pptp compression
XSR(aaa-group)#pptp encrypt mppe 128
XSR(aaa-group)#l2tp compression
XSR(aaa-group)#policy vpn
```

Configure DEFAULT group parameters including DNS and WINs servers, an IP pool, PPTP and L2TP values, and client VPN permission:

```
XSR(config)#aaa group DEFAULT
XSR(aaa-group)#dns server primary 0.0.0.0
XSR(aaa-group)#dns server secondary 0.0.0.0
XSR(aaa-group)#wins server primary 0.0.0.0
XSR(aaa-group)#wins server secondary 0.0.0.0
XSR(aaa-group)#ip pool test
XSR(aaa-group)#pptp compression
XSR(aaa-group)#pptp encrypt mppe 128
XSR(aaa-group)#l2tp compression
XSR(aaa-group)#policy vpn
```

Define a group for remote access XP users including DNS and WINs servers, an IP pool, PPTP and L2TP values, and client VPN permission:

```
XSR(config)#aaa group XPusers
XSR(aaa-group)#dns server primary 10.120.112.220
XSR(aaa-group)#dns server secondary 0.0.0.0
XSR(aaa-group)#wins server primary 10.120.112.220
XSR(aaa-group)#wins server secondary 0.0.0.0
XSR(aaa-group)#ip pool test
XSR(aaa-group)#pptp compression
XSR(aaa-group)#pptp encrypt mppe 128
```

```
XSR(aaa-group)#l2tp compression
XSR(aaa-group)#policy vpn
```

Configure the *local* AAA method for shared secret tunnels (NEM and client mode tunnels):

```
XSR(config)#aaa method local
XSR(aaa-method-radius)#group DEFAULT
XSR(aaa-method-radius)#qtimeout 0
```

Configure the *RADIUS* AAA method to authenticate remote access users:

```
XSR(config)#aaa method radius msradius default
XSR(aaa-method-radius)#backup test
XSR(aaa-method-radius)#enable
XSR(aaa-method-radius)#group DEFAULT
XSR(aaa-method-radius)#address ip-address 10.120.112.179
XSR(aaa-method-radius)#key welcome
XSR(aaa-method-radius)#auth-port 1812
XSR(aaa-method-radius)#acct-port 1646
XSR(aaa-method-radius)#attempts 1
XSR(aaa-method-radius)#retransmit 1
XSR(aaa-method-radius)#timeout 5
XSR(aaa-method-radius)#qtimeout 0
```

Define the Internet as all possible IP addresses:

```
XSR(config)#ip firewall network internet 1.0.0.0/32 external
```

Define the public VPN interface (crypto map):

```
XSR(config)#ip firewall network vpngateway 141.154.196.106 mask 255.255.255.255
internal
```

Define the private VPN interface (traditionally the FastEthernet 1 interface):

```
XSR(config)#ip firewall network f1 96.96.96.7 mask 255.255.255.255 internal
```

Define three trusted networks in the enterprise:

```
XSR(config)#ip firewall network trusted84 10.120.84.0 mask 255.255.255.0 internal
XSR(config)#ip firewall network trusted96 96.96.96.0 mask 255.255.255.0 internal
XSR(config)#ip firewall network trusted112 10.120.112.0 mask 255.255.255.0
internal
```

Specify remote trusted networks from NEM and Client mode tunnels:

```
XSR(config)#ip firewall network remote172 172.16.0.0 mask 255.255.0.0 internal
XSR(config)#ip firewall network remote192 192.168.0.0 mask 255.255.0.0 internal
```

Define the local pool network used for tunnel IP addresses:

```
XSR(config)#ip firewall network vsn 10.120.70.0 mask 255.255.255.0 internal
```

Define two networks to be used by OSPF:

```
XSR(config)#ip firewall network ospf 224.0.0.5 224.0.0.6 internal
XSR(config)#ip firewall network ssr 96.96.96.1 mask 255.255.255.255 internal
```

Define the NetSight network management station:

```
XSR(config)#ip firewall network netsight 10.120.84.3 mask 255.255.255.255
internal
```

Build two network groups to collect remote and trusted networks into manageable groups:

```
XSR(config)#ip firewall network-group trusted trusted84 trusted96 trusted112
XSR(config)#ip firewall network-group remote vsn remote172 remote192
```

Define service to support IPSec NAT traversal (Release 7.0 or later):

```
XSR(config)#ip firewall service ietfNatT eq 4500 gt 1023 udp
```

Define service for ISAKMP:

```
XSR(config)#ip firewall service ike eq 500 gt 499 udp
```

Define service for L2TP tunnels:

```
XSR(config)#ip firewall service l2tp eq 1701 eq 1701 udp
```

Define service for RADIUS authentication:

```
XSR(config)#ip firewall service radiusauth gt 1023 eq 1645 udp
```

Define service for RADIUS accounting:

```
XSR(config)#ip firewall service radiusacct gt 1023 eq 1646 udp
```

Write policies allowing traffic through the public VPN interface (crypto map) including enabling NAT Traversal:

```
XSR(config)#ip firewall policy nattraversal internet vpngateway nattraversal
allow bidirectional
XSR(config)#ip firewall policy PPTP internet vpngateway PPTP allow bidirectional
XSR(config)#ip firewall policy ike internet vpngateway ike allow bidirectional
XSR(config)#ip firewall policy l2tp internet vpngateway l2tp allow bidirectional
XSR(config)#ip firewall policy ietfNatT internet vpngateway ietfNatT allow
bidirectional
```

Allow HTTP and LDAP CRL retrieval out of the public VPN interface:

```
XSR(config)#ip firewall policy pki vpngateway internet HTTP allow
XSR(config)#ip firewall policy ldap vpngateway internet LDAP allow
```

Write policies permitting RADIUS and all TCP and UDP traffic from remote VPN networks into the corporate networks:

```
XSR(config)#ip firewall policy radiusauth f1a trusted radiusauth allow
XSR(config)#ip firewall policy radiusacct f1a trusted radiusacct allow
XSR(config)#ip firewall policy ANY_TCP remote trusted ANY_TCP allow bidirectional
XSR(config)#ip firewall policy ANY_UDP remote trusted ANY_UDP allow bidirectional
```

Allow IPSec (protocol 50) traffic from the Internet into the public VPN interface:

```
XSR(config)#ip firewall filter ipsec internet vpngateway protocol-id 50
bidirectional
```

Allow GRE traffic from the Internet into the public VPN interface:

```
XSR(config)#ip firewall filter gre internet vpngateway protocol-id 47
bidirectional
```

Allow OSPF through the firewall (trusted VPN interface) to the next hop corporate router:

```
XSR(config)#ip firewall filter ospf1 f1 ospf protocol-id 89 bidirectional
XSR(config)#ip firewall filter ospf2 ssr ospf protocol-id 89 bidirectional
XSR(config)#ip firewall filter ospf3 f1 ssr protocol-id 89 bidirectional
```

Permit ICMP traffic to flow from the trusted networks, through the VPN tunnels, to the remote trusted networks, and back:

```
XSR(config)#ip firewall filter icmp1 trusted remote protocol-id 1 bidirectional
```

Allow any IP address on the Internet to send ICMP traffic to the public VPN interface (the crypto map interface):

```
XSR(config)#ip firewall filter icmp2 vpngateway internet protocol-id 1 bi
```

Load the firewall configuration:

```
XSR(config)#ip firewall load
```

Globally enable the firewall. Even though you have configured and loaded the firewall, only invoking the following command "turns on" the firewall. Once enabled, if you are remotely connected, the firewall will close your session. Simply login again.

```
XSR(config)#ip firewall enable
```

Firewall Configuration for VRRP

This example briefly configures VRRP advertisements to be sent and received on a FastEthernet interface. You must configure two networks and a filter for the VRRP protocol (# 112). It is assumed you have already configured the VR and backup VR within the specified IP address range. Enable multicasting in both directions on FastEthernet interface 2:

```
XSR(config-if<F2>)#ip firewall ip-multicast both
```

Configure the IP address of the firewall networks *internal2* and *vrrp*, specifying a range between 80.0.0.1 and 80.255.255.254 and a multicasting host at 224.0.0.18/32, respectively. Finally, add a policy allowing VRRP advertisements to pass between private and external networks.

```
XSR(config-ifF2>)#ip address 80.0.0.1/8
XSR(config)#ip firewall network internal2 80.0.0.0 mask 255.0.0.0 internal
XSR(config)#ip firewall network vrrp 224.0.0.18 mask 255.255.255.255 internal
XSR(config)#ip firewall filter mult2 internal2 vrrp protocol-id 112
```

Firewall Configuration for RADIUS Authentication and Accounting

The following sample configuration employs the RADIUS method for AAA authentication. The commands in the section below configure Steel Belted RADIUS (SBR) as the RADIUS method, the server's IP address and encryption key, its RDIUS authentication and accounting ports (per IANA), and all four client services. Also configured are the backup RADIUS server *msradius* with one login attempt specified before the backup is accessed and five retransmit requests specified for service, and reconfigured queue and timeout values.

```
XSR(config)#aaa method radius sbr default
XSR(aaa-method-radius)#backup msradius
XSR(aaa-method-radius)#address ip-address 10.10.10.1
XSR(aaa-method-radius)#key acevpnfqwe
XSR(aaa-method-radius)#client vpn
XSR(aaa-method-radius)#client telnet
XSR(aaa-method-radius)#client firewall
XSR(aaa-method-radius)#client ssh
XSR(aaa-method-radius)#auth-port 1812
XSR(aaa-method-radius)#acct-port 1813
XSR(aaa-method-radius)#attempts 1
XSR(aaa-method-radius)#retransmit 5
XSR(aaa-method-radius)#timeout 10
XSR(aaa-method-radius)#qtimeout 0
```

Configure RADIUS network objects:

```
XSR(config)#ip firewall network internal 10.10.10.0 mask 255.255.255.0 internal
```

Configure policies allowing RADIUS authentication and accounting:

```
XSR(config)#ip firewall policy radius internal internal Radius allow bidirectional
XSR(config)#ip firewall policy RADacct internal internal Radius_ACCT allow
bidirectional
```

Configuring Simple Security

This configuration offers simple protection for the XSR. The firewall feature set is *not* used. First, perform standard port configuration:

```
XSR(config)#interface FastEthernet 1
XSR(config-if<F1>)#ip address 192.168.10.1 255.255.255.0
XSR(config-if<F1>)#no shutdown
XSR(config)#controller t1 0/2/0
XSR(config-controller<T1/2>)#no shutdown
XSR(config)#interface serial 2/0:0
XSR(config-if<S2/0:0>)#encapsulation ppp
XSR(config-if<S2/0:0>)#ip add 192.168.20.10 255.255.255.0
XSR(config-if<S2/0:0>)#no shutdown
```

Formulate access lists of allowed and prohibited network addresses:

```
XSR(config)#access-list 1 permit 192.168.10.0 0.0.0.255
XSR(config)#access-list 1 permit 192.168.20.0 0.0.0.255
XSR(config)#access-list 2 permit host 192.168.9.32
XSR(config)#access-list 100 deny ip any host 192.168.1.15
XSR(config)#access-list 100 deny any host 192.168.1.15 any
XSR(config)#access-list 100 deny ip tcp host 192.168.1.15 any
XSR(config)#access-list 100 permit ip 192.168.1.0 0.0.0.255 any
XSR(config)#access-list 100 permit ip any 192.168.1.0 0.0.0.255
```

Apply the access list to the network interfaces so that everything that is not permitted will automatically be filtered out, by default.

```
XSR(config)#interface fastethernet 1
XSR(config-if<F1>)#ip access-group 1 in
XSR(config-if<F1>)#ip access-group 1 out
XSR(config)#interface serial 2/0:0
XSR(config-if<S2/0:0>)#ip access-group 1 in
XSR(config-if<S2/0:0>)#ip access-group 1 out
```

For security reasons, you can limit the traffic type to certain ICMP/UDP/TCP/AH, ESP, and GRE ports. To use traffic type as a criteria, enter the extended **`access-list`** command, with numbers ranging from 100 to 199. The standard **`access-list`** command employs numbers ranging from 1 to 99 and can filter traffic by source IP address(es) only.

Write ACLS to permit Telnet and HTTP sessions. When the access list is applied to the port only, this type of traffic is allowed to pass through.

```
XSR(config)#access-list 100 permit tcp any any eq 21
XSR(config)#access-list 100 permit tcp any any eq 80
```

Create a *username* with an encrypted *password* (using the *secret* option) that is entered as clear text (using the *0* option).

```
XSR(config)#username larry password secret 0 larryj
```

RPC Policy Configuration

The following configuration creates policies which permit TCP RPC-based applications to flow from a *Branch* to *Corporate* network. You can use the keyword *bidirectional* if you expect the branch network to also have RPC-based services.

```
XSR(config)#ip firewall network Branch 192.168.1.1 192.168.1.10 internal
XSR(config)#ip firewall network Corporate 134.141.97.1 134.141.97.200 internal
XSR(config)#ip firewall service-group TCPRPC SunRPCTCP MsftRPCTCP
XSR(config)#ip firewall policy BtoC-TCPRPC Branch Corp SunRPCTCP allow
```

A

Alarms/Events, System Limits, and Standard ASCII Table

This appendix describes the configuration and memory limits of the XSR as well as system High, Medium and Low severity, firewall and NAT (separately described on page A-14) alarms and events captured by the router.

Recommended System Limits

The XSR suggests limits on the following configurable functions. These recommended limits are not *hard-coded*, nor are they the *Extreme Limits* referenced in "Memory Management" on page 2-37, but should serve as a guideline for purposes of memory carving.

Table A-4 XSR Limits

Function	@ 64 MBytes	@ 128 MBytes	@ 256 MBytes
Dynamic ARP entries	516	2000	4000
Static ARPs	200	200	200
Max Unresolved ARP Requests	500	500	500
Max Pending ARP Requests	128	128	128
Routing table entries	10000	12000	30000
Static routes	800	3500	5000
Secondary IP addresses	10	10	64
Virtual IP addresses	44 total, 11 per VR	44 total, 11 per VR	64
IP Helper addresses	50	50	50
UDP broadcast forwarding entries	50	50	50
OSPF LSA type 1	500	500	1000
OSPF LSA type 2	500	500	3000
OSPF LSA type 3	500	3500	7000
OSPF LSA type 4	500	3500	7000
OSPF LSA type 5	750	3500	7000
OSPF LSA type 7	250	250	500
ACL list entries	500	1000	1500
Users	25	25	256

Table A-4 XSR Limits (continued)

Function	@ 64 MBytes	@ 128 MBytes	@ 256 MBytes
SNMP read-only communities	20	20	20
SNMP read-write communities	20	20	20
SNMP trap servers	20	20	25
SNMP users	25	25	25
SNMP groups	100	100	100
SNMP views	50	50	10000
Interfaces	136	136	800
RIP networks	300	300	900
Dialer map classes	192	192	192
Dialer pool size	48	48	48
Frame Relay map classes	30	30	30
Sub-interfaces	30	30	30
DLCIs	300	300	300
PBR cache entries	1000	2000	2000
Route Map entries	1000	2000	2000
ADSL channel entries	30	210	210
AAA sessions	300	1500	4500
Authenticated tunnels (total of all tunnels)	300	1500	4500
IKE/IPSec tunnels (non-authenticated)	300	1500	1500
ISAKMP SAs.	600	1800	26250
IPSec SAs.	1200	6000	26250
L2TP tunnels.	300	1500	4500
PPTP tunnels.	255	255	255
ISAKMP proposals.	15	15	30
Crypto maps	40	80	200
Firewall networks	400	600	1000
Firewall services	400	600	1000
Firewall network groups	100	200	5000
Firewall service groups	100	200	5000
Firewall policies	500	1000	3000
Firewall gating rule limits	5000	1000	12000
Firewall filters	500	1000	3000
Firewall Java and ActiveX	100	200	200
Firewall sessions	10000	20000	60000

Table A-4 XSR Limits (continued)

Function	@ 64 MBytes	@ 128 MBytes	@ 256 MBytes
Firewall external hosts	5000	20000	20000
Firewall authentication entries	150	300	1000
Firewall fragmentation entries	100	200	600
Firewall FTP request entries	400	600	1000
Firewall UDP request entries	400	600	1000
Firewall Timer	100	200	200
Dynamic NAT sessions	4095	15000	45500
NAT static one-to-one mappings	1000	1000	1000
AAA users	1.5 MByte limit to *user.dat* Flash file		
Certificates	1.5 MByte limit to *cert.dat* Flash file		

System Alarms and Events

The XSR exhibits the following logging behavior for all except firewall and NAT alarms:

Table A-5 Alarm Behavior

When alarm logging is set to:	The XSR will log:
HIGH	HIGH severity alarms only
MEDIUM	MEDIUM and HIGH severity alarms
LOW	LOW, MEDIUM, and HIGH severity alarms
DEBUG	all alarms

Refer to the following table for all High severity alarms and events reported by the XSR. All of the following messages are USER_LEVEL facility except for those in bold and **red** text which are SECURITY_LEVEL.

Table A-6 High Severity Alarms/Events

Module	Message	Description
WEB	Failed to enable Web server	HTTP server is enabled improperly - cannot accept client link.
WEB	Failed to enable Web server	HTTP server is enabled improperly - cannot hear incoming requests.
WEB	Failed to enable Web server	HTTP server is enabled improperly - cannot set socket options.
WEB	Failed to enable Web server	HTTP server is enabled improperly - cannot bind socket.
WEB	Failed to enable Web server	HTTP server is enabled improperly - cannot listen to socket.
Various modules	Interface <interface name>, changed state to up	An interface link comes up.
Various modules	Interface <interface name>, changed state to down	An interface link goes down.

Table A-6 High Severity Alarms/Events (continued)

Module	Message	Description
T1E1	Receiver has Loss of Frame (Yellow Alarm).	T1/E1 physical port is detecting an OOF alarm.
T1E1	LOF alarm on receiver cleared.	T1/E1 physical port is not detecting an OOF alarm.
T1E1	Transmitting Remote Alarm (Yellow Alarm).	T1/E1 physical port is transmitting a remote alarm.
T1E1	Transmit Remote Alarm cleared.	T1/E1 physical port is not transmitting a remote alarm.
SYNC_ DRIV	The ISR could not be connected	Driver failed to connect the ISR to the BSP, so it will not start.
SYNC_ DRIV	Init string parse failure	Driver could not parse the initialization string so it will not start.
SYNC_ DRIV	Unrecoverable error	XSR has an un-recoverable error.
SYNC_ DRIV	OS initialization failure	The operating system failed to initialize the driver properly, so the XSR cannot start.
SYNC_ DRIV	Device not found	XSR could not be found on the PCI bus, so the driver cannot start.
SNMP	Failed to enable SNMP server	Failure to start SNMP server due to failure in the locking mechanism or the message queue is full.
SNMP	Failed to disable SNMP server	Failure to start SNMP server due to failure in the locking mechanism.
PLATF	System reset from <reason>, <warm|cold> start	Warm or cold start occurs for the following reasons: • Default config init: *dcfg* • Crash reset: *crsh* • CLI reset: *cli* • SNMP reset: *snmp* • Bootrom reset: *btrm* • Software checksum invalid: *cksm*
PLATF	Failed to initialize sysLog socket	Cannot create socket for sending syslogs.
PLATF	Failed to bind to sysLog port 514	Cannot bind to port 514 for sending syslogs.
ISDN	<BRI c/p>, SPID <spid string> Registered (CES <1|2)	BRI with a North American switch type successfully registers with the central office.
ISDN	<BRI c/p>, Unsolicited SME_TERM_REGISTER_ACK	BRI with a North American switch type registers with the central office but fails.
ISDN	<BRI c/p>, Registration Failed, Cause <number>	BRI with a North American switch type registers with the central office and fails. Causes include: *100* - SPID configuration error, *41* - Network timeout and *1* - Fit timeout
ISDN	%s Layer 2 Terminal %d is DOWN %s Layer 2 Terminal %d is UP	Q921 - LAP-D status, UP is normal operation. Terminal is 1 for PRI. For BRI it may be 1 or 2. 1 for ETSI and NTT. For North America 1 and 2 if two SPIDs are configured.
ISDN	%s Outgoing Call to %s %s Timed Out	For basic-NET3 BRI, XSR was unable to activate the BRI line for an outgoing call.
ISDN	%s Switch Offers call for BUSY channel %X	Error condition!

Table A-6 High Severity Alarms/Events (continued)

Module	Message	Description
ISDN	Incoming Call <BRI | Serial card/ port:channel> Connected to <calling no.> Unknown Call	An incoming call connected for test purposes will be disconnected within 30 seconds.
ISDN	North American BRI Interface %d requires SPID configuration	Configuration error.
ISDN	Call <BRI | Serial card/port:channel> Connected to <called_no.> Outgoing test CALL	A test call is placed from the console.
ISDN	Call <BRI | Serial card/port:channel> Disconnected from <number> <Outgoing test CALL | Unknown Call> Cause <passed from central office>	A test call is disconnected due to the standard ISDN cause. E.g. 16: normal clearing, 18: user does not answer.
ISDN	No Channel Available <destination name>	ISDN line was over subscribed.
ISDN	_FILE _LINE Out of memory	Unable to allocate memory.
ISDN	ISDN panic!!	Unable to create ISDN object.
ISDN	_FILE _LINE Out of memory	Unable to allocate memory.
ISDN	_FILE _LINE Out of memory	Unable to allocate memory.
ISDN	_FILE _LINE unexpected value	Unexpected message received.
ISDN	Interface BRI, changed state to up	Port has changed to Up state.
ISDN	Interface BRI, changed state to down	Port has changed to Down state.
FR	Serial a/b:d.e, started	Output from the *no shutdown* command.
FR	Serial a/b:d.e, shutting down	The interface has been manually shut down.
FR	Serial a/b:d.e, station UP, DLCI nnnn	The network reports the station is up.
FR	Serial a/b:d.e, station DOWN, DLCI nnnn	The network reports the station is up.
FR	Serial a/b:d cannot establish LMI, port is down	The network has not been responding for 5 minutes. You should check the connection.
FR	Serial a/b:d LMI - port DOWN	The LMI is reporting the port is Down.
FR	Serial a/b:d LMI - port UP	The network is reporting the port is Up.
FR	Serial a/b:d.e Config Error Aggregate CIR nnnn greater than measured speed nnn - CIR Assist is DISABLED	The total configured CIR exceeds the speed of the link and cannot guarantee CIR. Assist will not be operational.
ETH1_ DRIV	The device is stuck in reset	The FastEthernet 2 chip on the motherboard has severe problems - it cannot come out of reset and the FastEthernet 2 driver/interface cannot be started. The most likely cause is a hardware failure. When this alarm occurs, FastEthernet Interface 2 is not available.
ETH1_ DRIV	The device TX/RX is stuck in reset	The FastEthernet 2 chip on the motherboard has severe problems - either the transmitter or receiver cannot come out of reset and the FastEthernet 2 driver/interface cannot be started. The most likely cause of this alarm is a hardware failure, rendering FastEthernet port 2 unavailable.

Table A-6 High Severity Alarms/Events (continued)

Module	Message	Description
ETH1_ DRIV	The ISR could not be connected	This is internal configuration alarm occurs because the interrupt service routine (ISR) cannot be connected to the FastEthernet 2 interface/driver, rendering FastEthernet port 2 unavailable.
ETH1_ DRIV	Init string parse failure	This internal configuration alarm is due to the driver being unable to parse its initialization string, rendering FastEthernet port 2 unavailable.
ETH1_ DRIV	Unrecoverable error	The FastEthernet 2 chip on the motherboard has severe problems - a catastrophic failure. The most likely cause is a hardware failure. When this alarm occurs, FastEthernet port 2 is unavailable.
ETH1_ DRIV	OS initialization failure	This internal configuration alarm occurs because the operating system initialization of the driver/interface cannot be completed, rendering FastEthernet port 2 unavailable.
ETH1_ DRIV	Device not found	Most likely this occurs due to a hardware failure - the FastEthernet 2 chip cannot be found on the PCI bus (of the motherboard). When this occurs, FastEthernet port 2 is unavailable.
ETH0_ DRIV	The device is stuck in reset	The FastEthernet 1 chip on the motherboard has severe problems - it cannot come out of reset and the FastEthernet 1 driver/interface cannot be started. The most likely cause is a hardware failure. When this alarm occurs, FastEthernet port 1 is not available.
ETH0_ DRIV	The ISR could not be connected	This internal configuration alarm occurs because the interrupt service routine (ISR) cannot be connected to the FastEthernet 1 interface/driver, rendering FastEthernet port 1 unavailable.
ETH0_ DRIV	Init string parse failure	This internal configuration alarm occurs because the driver could not parse its initialization string, rendering FastEthernet port 1 unavailable.
ETH0_ DRIV	OS initialization failure	This internal configuration alarm occurs because the operating system initialization of the driver/interface cannot be completed, rendering the FastEthernet 1 interface unavailable.
CLI	Failed to create session for web access	Failure to start session for the Web.
CLI	Failed to create session for console access	Failure to start session for the Web.
CLI	Failed to create session for telnet access	Failure to start session for console.
CLI	Failed to create session for telnet access	Failure to start session for Telnet.
CLI	Failed to enable Telnet server	Cannot start Telnet server because socket open failed.
CLI	Failed to enable Telnet server	Cannot start Telnet server because socket bind failed.
CLI	Failed to enable Telnet server	Cannot start Telnet server because socket listen failed.
CLI	Failed to enable Telnet server	Failure to enable the Telnet server.
CLI	CLI Config mode released by user <username>	A user exits Configuration mode.
CLI	CLI Config mode released by user <username>	An unknown user exits Configuration mode.
CLI	CLI config mode released by startup-config	Configuration mode is released when the startup-config script finishes execution.

Table A-6 High Severity Alarms/Events (continued)

Module	Message	Description
CLI	**User: <username> logged in from address <IP address>**	**Login process failure due to invalid user ID or password through telnet session in CheckLogin().**
CLI	**User: <username> logged in from console**	**Login process failure due to invalid user ID or password through console session in CheckLogin().**
CLI	Failed to create CLI session	Insufficient memory at this time for data allocation.
CLI	**User: <username> failed to log in from address <IP address>**	**The user tries to login to administrator-reserved session through Telnet and fails due to invalid login ID in IsUserAdmin().**
CLI	Cannot open startup.cfg file! It may have not been generated yet.	The user cannot open the *startup-config* file in RestoreRunningConfig( ).
CLI	Could not seek to the end of startup.cfg file! Startup.cfg not restored!	Could not move to the end of the *startup-config* file in RestoreRunningConfig().
CLI	Could not get the size of startup.cfg file! Startup.cfg not restored!	The size of the *startup-config* file could not be obtained in RestoreRunningConfig().
CLI	Could not go to beginning of startup.cfg file! Startup.cfg not restored!	In RestoreRunningConfig()
CLI	Could not allocate memory for startup.cfg file! Startup.cfg not restored!	Out of memory in RestoreRunningConfig() during boot process.
CLI	Could not read startup.cfg! Startup.cfg not restored!	Failure reading *startup-config* during the boot process.
CLI	Startup-config error at line <line number>	*Startup-config* encountered an error at the specified line in the configuration file.
CLI	Running configuration can not be restored successfully!	Failure to restore configuration during boot process.
CLI	Failed to read CLI configuration files	Failure during boot process.
CLI	Line <line #> too long in config file <configuration file name> Skipping rest of file…	The specific line from *startup-config* file is too long to be processed during bootup.
CLI	CLI config mode released by user <username>	An unknown user exits configuration mode.
CLI	CLI Config mode locked by user <username>	Another user has accessed configuration mode and you are trying to access it.
CLI	CLI Config mode locked by startup-config	Configuration mode is locked when the startup-config script finishes execution.
CLI	CLI Config mode released by user <username>	A user exits Configuration mode.
CLI	Cannot delete the Admin	Occurs when you try to delete the administrator account.
ASYNC_ IDRIV	The ISR could not be connected	The driver failed to connect the ISR to the BSP, so it will note start.
ASYNC_ IDRIV	Init string parse failure	The driver could not parse the initialization string so it will not start.

Table A-6 High Severity Alarms/Events (continued)

Module	Message	Description
ASYNC_ IDRIV	Unrecoverable error	The XSR has an un-recoverable error.
ASYNC_ IDRIV	OS initialization failure	The operating system failed to initialize the driver properly, so the device cannot be started.
ASYNC_ IDRIV	Device not found	The device could not be found on the PCI bus, so the driver cannot be started.
FR	Serial 1/0, incompatible LMII,, detected [ANSI | ITU | ILMI]	The FR switch is running a different LMI than that configured for the interface. The detected LMI is displayed.
FR	Serial a/b:d, cannot establish LMI, port is down	No response from the attached device.

Refer to the table below for all Medium severity alarms and events reported by the XSR. All of the following messages are USER_LEVEL facility except for those in **bold** text which are SECURITY_LEVEL.

Table A-7 Medium Severity Alarms/Events

Module	Message	Description
T1E1	Not enough memory (Device: card number).	Error in allocating memory for T1E1 HW card.
T1E1	PCI device failure (Device: card number).	Error in initializing T1E1 HW card.
T1E1	PCI device failure (Device/Port: card number/port number).	Error in initializing T1E1 HW card.
T1E1	Not enough memory (Device: card number).	Error in allocating memory for T1E1 HW card.
T1E1	Not enough memory (Device/Port: card number/port number).	Error in allocating memory for T1E1 HW card.
T1E1	Internal system error (Device/Port: card number/port number).	Error in initializing T1E1 software.
T1E1	Could not register with MIB2 (Device/Port: card number/port number).	Failure to register the T1E1 subsystem with SNMP/MIB2 services.
T1	T1E1 PCI Init failed	Error in initializing T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Transmit Pending Queue.	Error in allocating memory for T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Transmit Done Queue.	Error in allocating memory for T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Transmit Descriptors.	Error in allocating memory for T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Receive Free Queue.	Error in allocating memory for T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Receive Done Queue.	Error in allocating memory for T1E1 HW card.

Table A-7 Medium Severity Alarms/Events (continued)

Module	Message	Description
T1	ERROR: Shared memory allocation failed for Receive Descriptors.	Error in allocating memory for T1E1 HW card.
T1	T1E1 PCI Init Failed.	Error in initializing T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Transmit Pending Queue.	Error in allocating memory for T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Transmit Done Queue.	Error in allocating memory for T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Transmit Descriptors.	Error in allocating memory for T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Receive Free Queue.	Error in allocating memory for T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Receive Done Queue.	Error in allocating memory for T1E1 HW card.
T1	ERROR: Shared memory allocation failed for Receive Descriptors.	Error in allocating memory for T1E1 HW card.
SNTP	SNTP request receive-timeout.	Failure to receive reply time from the server after one second.
SNMP	**SNMP auth failure from <ip address> <community>**	**An SNMP request received with an invalid community name. The community name with a maximum of 40 characters is displayed.**
SNMP	SNMP <trapType> trap. No route to host <IP address>	SNMP trap is added to retransmission queue because there is no route to the SNMP target server
SNMP	CLI config mode locked by SNMP user %s\n	Process SNMP packet and begin to set values on a parameter under config mode.
SNMP	CLI config mode released by SNMP user %s\n	SNMP finished setting value on a parameter under config mode.
SNMP	SNMP <trapType> trap dropped due to queue overflow	Too many traps are sent at a time causing the SNMP trap queue to overflow. As a result, the oldest item in the trap queue was dropped.
SNMP	No SNMP host is defined, traps are queued	An SNMP trap is enabled but the trap target server is not defined.
SNMP	SNMP <trapType> trap dropped when trying to send, cause unknown	Failure to send an SNMP trap to the trap target server. The cause of the failure is unknown.
SNMP	SNMP <trapType> trap. No route to host <ip address>	An SNMP trap is added to the retransmission queue because there is no route to the SNMP target server.
PPP	PPP CHAP authentication failed while authenticating remote peer's response	PPP CHAP authentication has failed while authenticating the remote peer's response to the challenge.
PPP	PPP CHAP authentication failed while being authenticated by remote peer	PPP CHAP authentication has failed while being authenticated by the remote peer.
PPP	PPP CHAP authentication success while authenticating remote peer's response	PPP CHAP authentication has passed while authenticating the remote peer's response.
PPP	PPP CHAP authentication success while being authenticated by remote peer	PPP CHAP authentication has passed while being authenticated by the remote peer.
PPP	PPP MS-CHAP authentication failed while authenticating remote peer's response	PPP MS-CHAP authentication has failed while authenticating the remote peer's response to the challenge.

Table A-7 Medium Severity Alarms/Events (continued)

Module	Message	Description
PPP	PPP MS-CHAP authentication failed while being authenticated by remote peer	PPP MS-CHAP authentication has failed while being authenticated by the remote peer.
PPP	PPP MS-CHAP authentication success while authenticating remote peer's response	PPP MS-CHAP authentication has passed while authenticating the remote peer's response.
PPP	PPP MS-CHAP authentication success while being authenticated by remote peer	PPP MS-CHAP authentication has passed while being authenticated by the remote peer.
PPP	PPP PAP authentication failed while authenticating remote peer	PPP PAP authentication has failed while authenticating the remote peer.
PPP	PPP PAP authentication failed while being authenticated by remote peer	PPP PAP authentication has failed while being authenticated by the remote peer.
PPP	PPP PAP authentication success while authenticating remote peer	PPP PAP authentication has passed while authenticating a remote peer.
PPP	PPP PAP authentication success while being authenticated by remote peer	PPP PAP authentication has passed while being authenticated by a remote peer.
PPP	Line protocol on Interface <interface name>, changed state to up	A line protocol on an interface comes up.
PPP	Line protocol on Interface <interface name>, changed state to down	A line protocol on an interface goes down.
PLATF	Failed to set syslog rx buf to zero	Cannot set recv buffer to zero to discard received syslogs.
ISDN	Incoming Call <BRI | Serial card/ port:channel> Connected to <calling no.> <destination name>	The incoming call is connected to the shown channel.
ISDN	Call <BRI | Serial card/port:channel> Connected to <called_no> <destination name>	Test call disconnected due to standard ISDN cause. E.g. 16: normal clearing, 18: user does not answer.
ISDN	Call <BRI | Serial card/port:channel> Disconnected from <number> <destination name> Cause <passed from CO>	The call is disconnected, due to the standard ISDN cause. E.g. 16 normal clearing, 18 User does not answer.
FR	Serial a/b:d Config Good Aggregate CIR nnn less than measured speed+D137 nnnn - CIR Assist is ENABLED	Total configured CIR is within 125% of the port measured speed - CIR assisting is enabled.
ETH0_ DRIV	PHY read operation time-out	The PHY chip on the FastEthernet 1 port has had an error (other than time-out) while processing a read request. Port functionality may or may not be affected: the port is still available, but its functionality may be diminished. The cause of this alarm is most likely HW failure.
ETH0_ DRIV	PHY read operation unsuccessful	The PHY chip on the FastEthernet 1 port has had an error (other than time-out) while processing a read request. Port functionality may or may not be affected: the port is still available, but its functionality may be diminished. The cause of this alarm is most likely HW failure.
ETH0_ DRIV	PHY write operation time-out	The PHY chip on the FastEthernet 1 interface has timed-out while processing a write request. When this occurs, port functionality may or may not be affected. The port will still be available, but its functionality may be diminished. The cause of this alarm is most likely HW failure.

Table A-7 Medium Severity Alarms/Events (continued)

Module	Message	Description
ETH0_ DRIV	PHY write operation unsuccessful	The PHY chip on the FastEthernet 1 interface has had an error (other than time-out) while processing a write request. When this occurs, port functionality may or may not be affected. The port will still be available, but its functionality may be diminished. The cause of this alarm is most likely HW failure.
DIAL	Dial muxIoctl call fail	Failure of the serial driver of the physical port connected to the modem.
DIAL	Modem on intf # is not responding	The modem is not connected or powered on.
DIAL	Invalid init string for modem on intf #	The modem does not recognize the initialization string. You should check the modem specification for a proper setup.
DIAL	Number busy for modem on intf #	The remote site dialed number is busy.
DIAL	No dial tone for modem on intf #	There is no dial tone for the modem PSTN line.
DIAL	No carrier for modem on intf #	The remote modem is not present at the site called by the local modem.
DIAL	No answer for modem on intf #	The remote modem is not configured for autoanswering.
DIAL	Connection dropped for modem on intf#s	The phone line connection is disconnected by the PSTN.
DIAL	Hangup fail for modem on intf #	Failure of the disconnect from the phone line command to the modem.
DIAL	Connection closed for modem on intf #	The phone line disconnect command is successful.
DIAL	Dialup connection opened for modem on intf #	The modem has successfully built a phone line link with the remote site.
CLI	Failed to create session for Telnet access	Telnet session could not be created at this time.
CLI	Unrecognized parameter <parameter string> at line <line #> in <file>	Invalid parameters from initialization configuration file during boot process. This file is different from the *startup.cfg*.
FR	serial a/b:d, started	Result from **`no shutdown`** command
FR	serial a/b:d, shutting down	**`Shutdown`** command
FR	serial a/b:d, station up, DLCI nnn	
FR	serial a/b:d, unknown LMI message	Cannot decode the received LMI Message.
FR	Serial a/b:d, dlci nn, No InVArp response from remote	The remote peer is not responding to Inverse ARP requests.
FR	Max. packet size based on CIR,BC,BE is less than 1514 bytes	

Refer to the table below for all Low severity alarms and events reported by the XSR. All of the following messages are USER_LEVEL facility except for those in **bold** text which are SECURITY_LEVEL.

Table A-8 Low Severity Alarms/Events

Module	Message	Description
T1E1	Receiver has Loss of Signal (Red Alarm).	Indicates that T1/E1 physical port is detecting LOS Alarm.
T1E1	LOS alarm on receiver cleared.	Indicates that T1/E1 physical port is not detecting LOS Alarm.

Table A-8 Low Severity Alarms/Events (continued)

Module	Message	Description
T1E1	Receive Remote Alarm Indication (Yellow Alarm).	Indicates that T1/E1 physical port is detecting RAI Alarm.
T1E1	Receive RAI alarm cleared.	Indicates that T1/E1 physical port is not detecting RAI Alarm.
T1E1	Receive Alarm Indication Signal (Blue Alarm).	Indicates that T1/E1 physical port is detecting AIS Alarm.
T1E1	Receive AIS cleared.	Indicates that T1/E1 physical port is not detecting AIS Alarm.
T1	Cablelength long failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	Cablelength short failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	Bert start failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	Bert profile failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	Bert abort failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	Clear controller counter failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	Load channel failed for slot/card/port:channel.	Load command sent to driver returned an error.
T1	Unload channel failed for slot/card/port:channel.	Unload command sent to driver returned an error.
T1	Start channel failed for slot/card/port:channel.	Start command sent to driver returned an error.
T1	Delete channel interface failed for slot/card/ port:channel.	Interface object delete could not be executed.
T1	Create channel interface failed for slot/card/ port:channel.	Interface object create could not be executed.
T1	Clock source failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	CRC failed for slot/card/port:channel.	Configuration command sent to driver returned an error.
T1	FDL failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	Framing failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	Invert data failed for slot/card/port:channel.	Configuration command sent to driver returned an error.
T1	Linecode failed for slot/card/port.	Configuration command sent to driver returned an error.
T1	Loopback configuration failed for slot/card/port.	Loopback command sent to driver returned an error.
T1	Loopback stop failed for slot/card/port.	Loopback stop command sent to driver returned an error.
T1	Load controller failed for slot/card/port.	Load command sent to driver returned an error.
T1	Unload controller failed for slot/card/port.	Unload command sent to driver returned an error.
T1	Start controller failed for slot/card/port.	Start command sent to driver returned an error.
T1	Stop controller failed for slot/card/port.	Stop command sent to driver returned an error.
T1	Bind controller failed for slot/card/port.	Bind command sent to driver returned an error.
T1	Delete controller object failed for slot/card/port.	T1E1 controller object delete could not be executed.
T1	Create controller object failed for slot/card/port.	T1E1 controller object create could not be executed.
SYNC_ DRIV	Recoverable error	XSR has a hard recoverable error.

Table A-8 Low Severity Alarms/Events (continued)

Module	Message	Description
SYNC_ DRIV	Packets lost > 255 (RX overrun)	Sum of packets lost due to RX FIFO overrun exceeded 255.
PP	Out of memory - frame dropped at port <port number>	Frame is dropped at the specified port from depleted memory.
PLATF	Need 'snmp-server system-shutdown' for SNMP reboot	SNMP configuration does not allow reboots.
FR	Serial a/b:d.e, packet arrived on unconfigured DLCI nnnn	Data is discarded
ETH1_ DRIV	Recoverable error	FastEthernet 2 chip (of the interface) has experienced a significant but recoverable problem. The interface has already corrected the problem by resetting itself.
ETH1_ DRIV	Packets lost > 255 (RX overrun)	Sum of packets this interface has lost (discarded) due to RX FIFO overrun exceeds 255. This alarm will occur only once.
ETH0_ DRIV	Recoverable error	FastEthernet 1 chip (of the interface) has experienced a significant, but recoverable problem. The interface has already corrected the problem by resetting itself.
ETH0_ DRIV	Packets lost > 255 (RX overrun)	Sum of packets this interface has lost (discarded) due to RX FIFO overrun exceeding 255. This alarm will occur once only.
CLI	**Login failed from address <IP address> due to timeout**	**Timeout error during login.**
ASYNC_ IDRIV	Recoverable error	The device has hard recoverable error.
ASYNC_ IDRIV	Packets lost > 255 (RX overrun)	Sum of packets lost due to RX FIFO overrun exceeded 255.
FR	Serial a/b:d unconfigured DLCI nn reported active by LMI	UNI-DCE has announced a DLCI as active but is not yet configured on the XSR. The DLCI should be configured, if required.
FR	Serial a/b:d Fragmentation not configured for DLCI nn - FRF.12 Packet received.	The remote side of the connection is *sending* FRF.12 packets, but the XSR is not configured locally to *transmit* FRF.12 packets. Any voice traffic may experience unnecessary delays.
FR	Serial a/b:d clock lost - speed detected nn bps	Frame Relay has detected a clock that is too slow and is bringing the interface operationally down until the clock reappears. If this problem persists, you may want to check the attached equipment or contact the service provider.
FR	Serial a/b:d clock recovered - speed detected nn bps	Frame Relay has detected a proper clock and is bringing the interface operationally up. LMI should re-establish shortly thereafter and DLCIS will start to pass traffic.
SERIAL	Serial a/b - DSR Down CTS Up (MUX_DOWN)	Serial port has detected an EIA transition which will cause an interface down condition. This alarm is additional to the high severity *Interface <interface name>, changed state to down}*
SERIAL	Serial a/b - DSR/CTS Down (MUX_DOWN)	Serial port has detected an EIA transition which will cause an interface down condition. This alarm is additional to the high severity *Interface <interface name>, changed state to down}*

Table A-8 Low Severity Alarms/Events (continued)

Module	Message	Description
SERIAL	Serial a/b - DSR Up CTS Down (MUX_UP)	Serial port has detected an EIA transition which will cause an interface up condition. This alarm is additional to the high severity *Interface <interface name>, changed state to up}*
SERIAL	Serial a/b - DSR/CTS Down (MUX_UP)	Serial port has detected an EIA transition which will cause an interface up condition. This alarm is additional to the high severity *Interface <interface name>, changed state to up}*
FR	serial a/b:d, un-configured DLCI nnn reported active by LMI	FR switch reports that the DLCI nn is active but the Dlci is not configured on the interface.
FR	serial a/b:d, packet arrived on unconfigured DLCI nnn	

Firewall and NAT Alarms and Reports

The XSR reports logging messages for firewall and NAT functionality as listed below. Low system-level logging messages are classified at Levels 4 or 6 while Medium system-level alarms are classified at Level 3. The format codes used in report text are defined as follows:

- *%CMD* - ACTIVEX, JAVA or CLS application commands
- *%IP1* - Source IP address. E.g.: 192.168.1.1
- *%IP2* - Source IP address -> Destination IP address. E.g.: 192.168.1.1 -> 10.10.10.1
- *%IP_P2* - Source IP address and port # ->Destination IP address and port #. E.g.: 192.168.1.1(12352) -> 10.10.10.1(21)
- *%IP_TC* - Source IP address with type *x* & code *x*. E.g.: 192.168.1.1 type 8 (echo) code 2 (subset)
- *%IP2_ICMP* - Source IP address -> Destination IP address with type *x* and code *x*. E.g.: 192.168.1.1 -> 10.10.10.1 type 8 code 0
- *%IP2_X* - Source IP address -> Destination IP address with protocol # (0-255) (in hexidecimal format). E.g.: 192.168.1.1 -> 10.10.10.1 protocol 7
- *%POL* - Name of the firewall policy that causes this report, that is: allow log, TCP, or UDP

Table A-9 Firewall and NAT Alarms

Severity	Report Text
0 - EMERG	Bad NAT entry pointer passed to freeAddrTransEntry()
0 - EMERG	Init: Failed to allocate memory for NAT cache
1 - ALERT	DHCP module resolved a new IP Address for NAT: %IP1
1 - ALERT	DHCP module resolved a new IP Mask for NAT: %IP1
1 - ALERT	DHCP module resolved a new router's IP address: %IP1
1 - ALERT	NAT: Attempt made to bypass NAT by a GRE packet, %IP2
1 - ALERT	NAT: Attempt made to bypass NAT, %IP_P2
2 - CRIT	Init: Error reading NAT Mapper table
3 - ERROR	NAT: No NAT entry found, %IP_P2

Table A-9 Firewall and NAT Alarms (continued)

Severity	Report Text
3 - ERROR	NAT: No NAT entry found, %IP_P2
3 - ERROR	NAT: TCP reset, NAT port %d, %IP_P2
3 - ERROR	UDP: NAT unable to forward packet, %IP_P2
4 - WARNING	NAT table is full
4 - WARNING	NAT: TCP connection closed, freeing NAT port %d
4 - WARNING	Purging NAT Entry for port %d
5- NOTICE	NAT: Failed to send ARP Request packet to %IP1
5- NOTICE	NAT: Failed to send ARP Request packet to default router %IP1
0 - EMERG	Init: Failed to allocate external host memory
0 - EMERG	Init: Failed to allocate memory for auth host table
0 - EMERG	Init: Failed to allocate memory for Fragmentation cache
0 - EMERG	Init: Failed to allocate memory for FTP Request pool
0 - EMERG	Init: Failed to allocate memory for UDP Request pool
0 - EMERG	Init: Failed to allocate session memory
0 - EMERG	Init: Session Mgr Failed to create aging timer
0 - EMERG	Init: Session Mgr failed to create FloodCheck timer
1 - ALERT	Deny: TCP SYN backlog queue is full. %IP_P2
1 - ALERT	Deny: TCP SYN+ACK backlog queue is full. %IP_P2
1 - ALERT	Empty IP fragment
1 - ALERT	External Host pool exhausted
1 - ALERT	FTP PORT Command has bad IP Address %IP2
1 - ALERT	Init: Error reading ActiveX filter
1 - ALERT	IP fragment offset plus length exceeds the maximum IP datagram length
1 - ALERT	IP fragment with negative fragmentation offset
1 - ALERT	Maximum fragments for a single IP packet reached
1 - ALERT	Session pool exhausted
1 - ALERT	TCP: Detected portscan. %IP_P2
1 - ALERT	TCP: Detected SYN Flood attack. %IP_P2
1 - ALERT	TCP: Duplicated session %IP_P2
1 - ALERT	TCP: External host already exists %IP_P2
1 - ALERT	TearDrop-like attack: invalid fragmentation offset value
1 - ALERT	UDP fragmentation attack: constructed payload larger than specified in UDP header
1 - ALERT	UDP fragmentation attack: constructed payload less than specified in the UDP header
1 - ALERT	UDP: Duplicated session %IP_P2

Table A-9 Firewall and NAT Alarms (continued)

Severity	Report Text
1 - ALERT	UDP: Detected UDP Flood attack %IP_P2
1 - ALERT	UDP: Duplicated external host %IP_P2
2 - CRIT	Init: Error reading ATE SR entries
2 - CRIT	Init: Error reading java filter
2 - CRIT	Init: Error reading selective IP ranges for ActiveX filtering
2 - CRIT	Init: Error reading selective IP ranges for Java filtering
2 - CRIT	Init: Error reading translation host entries
2 - CRIT	Init: Failed to allocate memory for %d IP ranges for ActiveX Filters
2 - CRIT	Init: Failed to allocate memory for %d IP ranges for Java Filters
2 - CRIT	Init: Failed to allocate memory for ATEs, entries: %d
2 - CRIT	Init: Failed to allocate memory for CLS Commands
2 - CRIT	Init: Failed to allocate memory for CLS commands
2 - CRIT	Init: Failed to allocate memory for CLS Control module
2 - CRIT	Init: Failed to allocate memory for gating rules
2 - CRIT	Init: Failed to allocate memory for gating rules: %d
2 - CRIT	Init: Failed to allocate memory for host ranges: %d
2 - CRIT	Init: Failed to allocate memory for host table entries
2 - CRIT	Init: Failed to allocate memory for host table entries: %d
2 - CRIT	Init: Failed to allocate memory for secure host ranges: %d
2 - CRIT	Init: Failed to allocate memory for security classes
2 - CRIT	Init: Failed to allocate memory for security classes: %d
2 - CRIT	Init: Failed to allocate memory for service rules: %d
2 - CRIT	Init: Failed to allocate memory for service tuples
3 - ERROR	Deny: UDP under Flood attack %IP_P2
3 - ERROR	Authentication cache overflowed
3 - ERROR	Could not create timer event, error %d
3 - ERROR	Deny: ActiveX control %CMD, %IP2
3 - ERROR	Deny: Badly formed FTP PORT response, %IP_P2
3 - ERROR	Deny: GRE packet, %IP2
3 - ERROR	Deny: ICMP %IP2
3 - ERROR	Deny: ICMP fragmented packet %IP2_X
3 - ERROR	Deny: ICMP message too short, length %d, %IP_TC
3 - ERROR	Deny: ICMP packet with bad checksum, %IP_TC
3 - ERROR	Deny: ICMP Unsolicited ICMP reply packet. %IP2_ICMP

Table A-9 Firewall and NAT Alarms (continued)

Severity	Report Text
3 - ERROR	Deny: ICMP unsupported packet %IP2_ICMP
3 - ERROR	Deny: java applet %CMD, %IP_P2
3 - ERROR	Deny: No filter for %s, %IP_2
3 - ERROR	Deny: No filter for ICMP, %IP_2
3 - ERROR	Deny: no matching filter, %IP2_ICMP
3 - ERROR	Deny: OSPF packet, %IP2
3 - ERROR	Deny: TCP Christmas Tree Packet, %IP_P2
3 - ERROR	Deny: TCP SYN+ACK packet blocked.
3 - ERROR	Deny: TCP SYN+ACK packet without ever seeing SYN packet. %IP_P2
3 - ERROR	Deny: TCP ACK packet, session not open %IP_P2
3 - ERROR	Deny: TCP Con_Req %IP_P2
3 - ERROR	Deny: TCP Conn IP_P2
3 - ERROR	Deny: TCP IN Con_Req - SYN Flood attack %IP_P2
3 - ERROR	Deny: TCP Possible break-in attempt, %IP_P2
3 - ERROR	Deny: TCP Un-Auth host %IP_P2
3 - ERROR	Deny: TCP, no policy, %IP_P2
3 - ERROR	Deny: UDP %IP_P2
3 - ERROR	Deny: UDP, no policy applies, %IP_P2
3 - ERROR	Deny: UDP, no policy, %IP_P2
3 - ERROR	Failed to allocate memory for a reply packet
3 - ERROR	Failed to install protected mode timer tick handler
3 - ERROR	ICMP Flood attack detected %IP_P2
3 - ERROR	Index of an inactive timer entry passed to osUntimeOut() call
3 - ERROR	Init: Failed to allocate memory for TimerEntries
3 - ERROR	Init: Failed to allocate memory for user authentication
3 - ERROR	Internal error
3 - ERROR	IP fragment cache entry purged
3 - ERROR	IP header checksum does not match, %IP_P2
3 - ERROR	osUnTimeOut() called with a bad index = %d
3 - ERROR	Received fragmented Packet without the initial fragment
3 - ERROR	TCP header checksum does not match, %IP_P2
3 - ERROR	TCP: ACK packet in the TCP three-way handshake sequence was blocked. %s
3 - ERROR	TCP: Detected possible process table attack using sequence number guessing. %IP_P2
3 - ERROR	TCP: Maximum allowed inbound connections exceeded from host %IP_P2

Table A-9 Firewall and NAT Alarms (continued)

Severity	Report Text
3 - ERROR	TCP: Non-empty ACK packet in TCP three-way handshake sequence %IP_P2
3 - ERROR	TCP: RST packet indicating non-existing service was blocked %IP_P2
3 - ERROR	UDP: Maximum allowed inbound connections exceeded from host %IP_P2
3 - ERROR	UDP: Request Entry pool is empty
3 - ERROR	Unsupported ICMP packet %IP2_ICMP
4 - WARNING	%s session purged %IP_P2
4 - WARNING	Bad FTP Entry
4 - WARNING	Badly formed FTP PORT command, %IP_P2
4 - WARNING	Cannot schedule any more timer events
4 - WARNING	CLS blocked FTP request, command: %CMD %IP_P2
4 - WARNING	CLS blocked HTTP request, command: %CMD %IP_P2
4 - WARNING	CLS blocked HTTP stray packet, %IP_P2
4 - WARNING	CLS blocked SMTP request, command: %CMD %IP_P2
4 - WARNING	CLS blocked stray SMTP packet, %IP_P2
4 - WARNING	Could not allocate TCP buffer for H.323 connection. %IP_P2
4 - WARNING	Deny: User Authentication packet, %IP2
4 - WARNING	FTP packet cannot be forwarded since no free NAT port available for FTP
4 - WARNING	FTP Request pool is empty
4 - WARNING	IP fragment cache table is empty
4 - WARNING	Log: TCP, Policy %POL, %IP_P2
4 - WARNING	Log: UDP, Policy %POL, %IP_P2
4 - WARNING	Permit: ActiveX control %CMD, %IP_P2
4 - WARNING	Permit: Allow-log Filter %POL, %IP_P2
4 - WARNING	Permit: EGP packet, %IP2
4 - WARNING	Permit: GRE packet, %IP2
4 - WARNING	Permit: ICMP %IP2_ICMP
4 - WARNING	Permit: IGMP packet, %IP2
4 - WARNING	Permit: IGRP packet, %IP2
4 - WARNING	Permit: java applet %CMD, %IP_P2
4 - WARNING	Permit: OSPF packet, %IP2
4 - WARNING	Permit: TCP BGP packet, %IP2
4 - WARNING	Permit: TCP Con_Est, %IP_P2
4 - WARNING	Permit: TCP Con_Req, %IP_P2
4 - WARNING	Permit: UDP %IP_P2

Table A-9 Firewall and NAT Alarms (continued)

Severity	Report Text
4 - WARNING	TCP connection closed %IP_P2
4 - WARNING	TCP new session request %IP_P2
4 - WARNING	TCP Out-Of-Sequence table is full
4 - WARNING	UDP: Bad entry found in UDP Request cache table
4 - WARNING	UDP: Bad response, %IP_P2
4 - WARNING	UDP: Received Bad BOOTP Frame
4 - WARNING	UDP: Unsolicited Req. (Resp expected), Ext->Int: %IP2
4 - WARNING	UDP: Unsolicited Resp. (Req expected), %IP2
4 - WARNING	UDP: Unsolicited response, %IP_P2
4 - WARNING	UDP: new session request %IP_P2
4 - WARNING	Subnet: aa.bb.cc.0 added to Sync Attack Watch list
4 - WARNING	Subnet: aa.bb.cc.0 removed from Sync Attack Watch list
4 - WARNING	Host a.b.c.d added to Sync Attack blocking list
4 WARNING	Host a.b.c.d removed from Sync Attack blocking list
6 - INFO	ECHO request from %IP1
6 - INFO	UDP: %d pending response, %IP_P2

Standard ASCII Character Table

The following table displays standard ASCII characters for referencing SNMP conventions found in “Configuration Examples” on page 2-41.

Figure A-17 Standard ASCII Character Table

32: **<space>**	33: **!**	34: **“**	35: **#**	36: **$**	37: %
38: **&**	40: **(**	41: **)**	42: *	43: **+**	44: **,**
45: **-**	46: **.**	48: **0**	49: **1**	50: **2**	51: **3**
52: 4	53: **5**	54: **6**	56: **8**	57: **9**	58: **$**
59: **;**	60: **<**	61: **=**	62: **>**	64: **@**	65: **B**
66: **B**	67: **C**	68: **D**	69: **E**	70: **F**	72: **H**
73: **I**	74: **J**	75: **K**	76: **L**	77: **M**	78: **N**
80: **P**	81: **Q**	82: **R**	83: **S**	84: **T**	85: **U**
86: **V**	88: **X**	89: **Y**	90: **Z**	91: **[**	92: \
93: **]**	94: **^**	96: **‘**	97: **a**	98: **b**	99: **c**
100: **d**	101: **e**	102: **f**	104: **h**	105: **i**	106: **j**

107: **k**	108: **l**	109: **m**	110: **n**	112: **p**	113: **q**
114: **r**	115: **s**	116: **t**	117: **u**	118: **v**	120: **x**
121: **y**	122: **z**	123: **{**	124:	125: **}**	126: ~

B

XSR SNMP Proprietary and Associated Standard MIBs

This appendix lists and describes XSR-supported SNMP tables and objects for the following standard (partial listing) and proprietary MIBS:

Service Level Reporting MIB Tables

The XSR supports the following SLR tables, whose fields are described in the following pages:

- *etsysSrvcLvlMetricTable*
- *etsysSrvcLvlOwnerTable*
- *etsysSrvcLvlHistoryTable*
- *etsysSrvcLvlNetMeasureTable*
- *etsysSrvcLvlAggrMeasureTable*

etsysSrvcLvlMetricTable

Each Enterasys service level standardized metric defined in the MIB is described in the etsysSrvcLvlMetricTable. This table is not configurable. Supported metrics and their type are listed in the table below.

Table B-10 etsysSrvcLvlMetricTable

etsysSrvcLvlMetric Description	etsysSrvcLvlMetricType
RoundTripPacketLost	Network
RoundTripPacketLossAverage	Aggregate
RoundTripDelay	Network
RoundTripDelayAverage	Aggregate
RoundTripIpdv	Aggregate

etsysSrvcLvlOwnerTable

A management entity interested in creating and activating remote SLA measurements must previously be registered in the Service Level Owners Table which contains owner's contact information. The MIB indicates that there should be at least one owner **monitor** in the *etsysSrvcLvlOwnerTable*. So, by default, the table comprises *one* row. Unless you specify the *quota*, *IP address*, *Email* or *SMS*, the default **monitor** entry will not be stored in the *startup-config* file. All other entries will be stored in the *startup-config*, though.

Data in this table can be configured via SNMP as well as the **`rtr owner`** CLI command. You create an owner entry by setting the status field of the new entry to *CreateAndWait*. You can modify the parameters and even the row becomes active. But, once there is an *rtr entry* which binds to a particular owner, you cannot change the parameter for the bounded owner. Also, you cannot remove the owner monitor nor add the same owner twice. The status of the owner **monitor** is always active and cannot be changed.

Table B-11 etsysSrvcLvlOwnerTable

Field	Description
etsysSrvcLvlOwnersOwner	monitor
etsysSrvcLvlOwnersGrantedMetrics	Read only
etsysSrvcLvlOwnersQuota	700
etsysSrvcLvlOwnersIpAddressType	Ipv4 (1)
etsysSrvcLvlOwnersIpAddress	
etsysSrvcLvlOwnersEmail	
etsysSrvcLvlOwnersSMS	1234567 (phone number must not contain space)
etsysSrvcLvlOwnersStatus	active

etsysSrvcLvlHistoryTable

This table contains measurements of *Service Level History* entries. It is not SNMP-configurable and the total size allocated per owner is set but can be configured via the CLI **`rtr`** command. You can use the **`show rtr`** history command to view data in this table.

Table B-12 etsysSrvcLvlHistoryTable

Field	Example Value
etsysSrvcLvlHistorySequence	1

Table B-12 etsysSrvcLvlHistoryTable

Field	Example Value
etsysSrvcLvlHistoryTimestamp	Second since Jan 2000 see also RFC-1305
etsysSrvcLvlHistoryValue	10 (depends on what is measured)

etsysSrvcLvlNetMeasureTable

Entries in the *Service Level Network Measurement Table* display several metric measurements per packet exchange. Each measurement step produces a single result per metric with measurement intervals and metrics saved in the Table. Once the *etsysSrvcLvlAggrMeasureTable* becomes active, you cannot modify any fields in this table, but, by setting the *etsysSrvcLvlAggrMeasureStatus* back to *notInService*, you can modify the *etsysSrvcLvlNetMeasureBeginTime* and *etsysSrvcLvlNetMeasureDuration*, and set the *etsysSrvcLvlAggrMeasureStatus* back to active. This triggers the SLA agent to reschedule the measurement. This is consistent with how the CLI command operates.

Table B-13 etsysSrvcLvlNetMeasureTable

Field	Example	CLI command
etsysSrvcLvlNetMeasureName	ip-icmp-one-way-packet-loss	**`tag`** - aliased to etsysSrvcLvlAggrMeasureName
etsysSrvcLvlNetMeasureMetrics	00:01:00:00:10	Not configurable. All supported network metrics
etsysSrvcLvlNetMeasureBeginTime	Seconds since Jan2000	**`rtr schedule -`** aliased to etsysSrvcLvlAggrMeasureBeginTime. Note that the reserved most significant bit is ignored as is the fractional part of the second bit.
etsysSrvcLvlNetMeasureDurationUnit	second	Units for **`rtr schedule`**. Not configurable
etsysSrvcLvlNetMeasureDuration	100	**`rtr schedule life`** - aliased to etsysSrvcLvlAggrMeasureDuration
etsysSrvcLvlNetMeasureHistorySize	10	**`buckets-of-history-kept -`** aliased to etsysSrvcLvlAggrMeasureHistorySize
etsysSrvcLvlNetMeasureFailureMgmtMode	Auto	Not configurable
etsysSrvcLvlNetMeasureResultMgmt	wrap	Not configurable
etsysSrvcLvlNetMeasureSrcTypeP	ip.icmp	Not configurable
etsysSrvcLvlNetMeasureSrc	1.1.1.1	**`type`**
etsysSrvcLvlNetMeasureDstTypeP	ip.icmp	Not configurable
etsysSrvcLvlNetMeasureDst	1.1.1.2	**`type`**
etsysSrvcLvlNetMeasureTxMode	periodic	Not configurable
etsysSrvcLvlNetMeasureTxPacketRateUnit	second	Not configurable
etsysSrvcLvlNetMeasureTxPacketRate	1(second)	**`frequency`**. Frequency must be longer than timeout
etsysSrvcLvlNetMeasureDevtnOrBustSize	0	Not configurable
etsysSrvcLvlNetMeasureMedOrIntBurstSize	0	Not configurable
etsysSrvcLvlNetMeasureLossTimeout	4 (milliseconds)	**`timeout`**. Timeout must be shorter than frequency
etsysSrvcLvlNetMeasureL3PacketSize	64	request-data-size
etsysSrvcLvlNetMeasureDataPattern	abcd (repeats in the payload)	Not configurable

Table B-13 etsysSrvcLvlNetMeasureTable (continued)

Field	Example	CLI command
etsysSrvcLvlNetMeasureMap	Network in city A	**`map`** - aliased to etsysSrvcLvlAggrMeasureMap
etsysSrvcLvlNetMeasureSingletons	5	**`show rtr operational-state`**. Not configurable. Number of packets sent thus far for this metric
etsysSrvcLvlNetMeasureOperState	Stopped (2)	**`show rtr operational-state`**. Not configurable. Set by the operState base in the **`rtr schedule`**

etsysSrvcLvlAggrMeasureTable

Entries in the Service Level Aggregate Measurement Table display several metric measurements per packet exchange. Each step of the measurement produces a single result with the interval and metric saved in the *etsysSrvcLvlHistoryTable*. A measurement entry is created by setting the status field of the new entry to *CreateAndWait*.

Note: Once the table becomes active, no field can be modified, with the following exceptions:

* Set the status to *destroy*, which removes these entries: *aggregate measure, associated network measure **and** associated history.*

* Set the status to *notInService*. By setting it back to *notInService*, you can modify the *etsysSrvcLvlAggrMeasureBeginTime*, *etsysSrvcLvlAggrMeasureDuration, a*nd set the status back to active. This will trigger the SLA agent to reschedule the measurement. This is consistent with how the CLI command operates.

Table B-14 etsysSrvcLvlAggrMeasureTable

Field	Example	CLI command
etsysSrvcLvlAggrMeasureName	ip-icmp-one-way-packet-loss-average:	**tag** - aliased to etsysSrvcLvlNetMeasureName
etsysSrvcLvlAggrMeasureMetrics	00:00:00:00:2C	All supported aggr metrics
etsysSrvcLvlAggrMeasureBeginTime	Seconds since Jan2000	**rtr schedule** - aliased to etsysSrvcLvlNetMeasureBeginTime
etsysSrvcLvlAggrMeasureAggrPeriodUnit	second	Not configurable
etsysSrvcLvlAggrMeasureAggrPeriod	100	aggregate period
etsysSrvcLvlAggrMeasureDurationUnit	second	Not configurable
etsysSrvcLvlAggrMeasureDuration	100	**rtr schedule life** - aliased to etsysSrvcLvlNetMeasureDuration
etsysSrvcLvlAggrMeasureHistorySize	10	**buckets-of-history-kept -** aliased to etsysSrvcLvlNetMeasureHistorySize.
etsysSrvcLvlAggrMeasureStorageType	non-volatile (3)	Not configurable
etsysSrvcLvlAggrMeasureResultsMgmt	wrap	Not configurable
etsysSrvcLvlAggrMeasureHistoryOwner	monitor	Can only be etsysSrvcLvlNetMeasurOwner of the corresponding entry

Table B-14 etsysSrvcLvlAggrMeasureTable (continued)

Field	Example	CLI command
etsysSrvcLvlAggrMeasureHistoryOwnerIndex	1 (Whatever is shown on the *etsysSrvcLvlNetMeasureTable* for the corresponding entry)	Can only be etsysSrvcLvlNetMeasureIndex of the corresponding entry
etsysSrvcLvlAggrMeasureHistoryMetric	0	Not configurable
etsysSrvcLvlAggrMeasureAdminState	Stop	**[no] rtr schedule** Note that this is overwritten by the status. If status become active, the adminState is always Start; if status changes from active to notInService, the adminState is Stop
etsysSrvcLvlAggrMeasureMap	Network in city A	**map** - aliased to etsysSrvcLvlNetMeasureMap
etsysSrvcLvlAggrMeasureStatus	active	Once active, you cannot modify any fields except deleting the row or setting the status to notInService

BGP v4 MIB Tables

The XSR supports the following BGP v4 tables, whose fields are described in the following pages:

- General Variables
- Peer Table
- Received Path Attribute Table
- Traps

General Variables Table

Table B-15 General Variables Table

Field	CLI Command
bgpVersion	The vector of supported BGP protocol version numbers. Each peer negotiates the version from this vector. Versions are identified via the string bits contained within this object.
bgpLocalAs	The local autonomous system number, ranging from 0 to 65535.
bgpIdentifier	The BGP Identifier of local system.

BGP v4 Peer Table

Table B-16 BGP v4 Peer Table

Field	Description
bgpPeerIdentifier	The BGP Identifier of this entry's BGP peer.
bgpPeerState	The BGP peer connection state including: idle(1), connect(2), active(3), opensent(4), openconfirm(5), or established(6)

Table B-16 BGP v4 Peer Table (continued)

Field	Description
bgpPeerAdminStatus	The desired state of the BGP connection. A transition from *stop* to *start* will cause the BGP Start Event to be generated. A transition from *start* to *stop* will cause the BGP Stop Event to be generated. This value can be used to restart BGP peer connections. Use care in not providing write access to this object without adequate authentication.
bgpPeerNegotiatedVersion	The negotiated version of BGP running between two peers.
bgpPeerLocalAddr	The local IP address of this entry's BGP connection.
bgpPeerLocalPort	The local port for the TCP connection between the BGP peers, ranging from 0 to 65535. This field is not readable.
bgpPeerRemoteAddr	The remote IP address of this entry's BGP peer.
bgpPeerRemotePort	The remote part for the TCP connection between BGP peers, ranging from 0 to 65535. Note that objects *bgpPeerLocalAddr, bgpPeerLocalPort, bgpPeerRemoteAddr* and *bgpPeerRemotePort* provide the appropriate reference to the standard MIB TCP link table. This field is not readable.
bgpPeerRemoteAs	The remote autonomous system number. Range: 0 - 65535.
bgpPeerInUpdates	The number of BGP UPDATE messages received on this connection. This object should be initialized to be zero (0) when the connection is established.
bgpPeerOutUpdates	The number of BGP UPDATE messages transmitted on this connection. This object should be initialized to zero (0) when the connection is established.
bgpPeerInTotalMessages	The total number of messages received from the remote peer on this connection. This object should be initialized to zero (0) when the connection is established.
bgpPeerOutTotalMessages	The total number of messages transmitted to the remote peer on this connection. This object should be initialized to zero (0) when the connection is established.
bgpPeerLastError	The last error code and subcode seen by this peer on this connection. If no error has occurred, this field is zero (0). Otherwise, the first byte of this two-byte OCTET STRING contains the error code, and the second byte the subcode.
bgpPeerFsmEstablishedTransitions	The total number of times the BGP FSM transitioned into the established state.
bgpPeerFsmEstablishedTime	This timer indicates the interval in seconds this peer has been in the Established state or how long since this peer was last in the Established state. It is set to zero (0) when a new peer is configured or the router is booted.
bgpPeerConnectRetryInterval	The interval for the ConnectRetry timer. Range: 1 to 65535 seconds. The suggested value for this timer is 120 seconds.
bgpPeerHoldTime	The intervalfor the Hold Timer established with the peer, ranging from 0 to 65535 seconds. The value for this object is calculated by this BGP speaker by using the smaller of the value in *bgpPeerHoldTimeConfigured* and the Hold Time received in the OPEN message. This value must be at least three seconds if it is not zero (0) in which case the Hold Timer has not been established with the peer, or the value of *bgpPeerHoldTimeConfigured* is zero(0). This field is read only.

Table B-16 BGP v4 Peer Table (continued)

Field	Description
bgpPeerKeepAlive	Interval for the KeepAlive timer established with the peer, range: 1-21845 seconds. The value is calculated by this BGP speaker such that, when compared with *bgpPeerHoldTime*, it has the same proportion as *bgpPeerKeepAliveConfigured* has when compared with *bgpPeerHoldTimeConfigured*. If the value of this object is zero (0), it indicates that the KeepAlive timer has not been established with the peer, or, the value of *bgpPeerKeepAliveConfigured* is zero (0).
bgpPeerHoldTimeConfigured	NOTE: Since the configuration of HoldTime for a particular neighbor is not supported from the CLI, setting this parameter is disallowed. A read-only error will occur if a set is tried. The interval for the Hold Time is configured for this BGP speaker with this peer, ranging from 0 to 65535 seconds. This value is placed in an OPEN message sent to this peer by this BGP speaker, and is compared with the Hold Time field in an OPEN message received from the peer when determining the Hold Time (*bgpPeerHoldTime*) with the peer. This value must not be less than three seconds if it not zero (0) in which case the Hold Time will not be established with the peer. Suggested value for this timer is 90 seconds.
bgpPeerKeepAliveConfigured	The interval for the KeepAlive timer configured for this BGP speaker with this peer, ranging from 0-21845 seconds. This value determines only the KEEPALIVE messages' frequency relative to the value specified in *bgpPeerHoldTimeConfigured.* The actual time interval for the KEEPALIVE messages is indicated by *bgpPeerKeepAlive*. A reasonable maximum value for this timer would be configured at one-third of *bgpPeerHoldTimeConfigured*. If the value of this object is zero (0), no periodical KEEPALIVE messages are sent to the peer after the BGP connection has been established. Suggested value: 30 seconds.
bgpPeerMinASOriginationInterval	The interval for the *MinASOriginationInterval* timer, ranging from 1 to 65535 seconds. Suggested value: 15 seconds.
bgpPeerMinRouteAdvertisementInterval	The interval for *MinRouteAdvertisementInterval* timer, ranging from 1 to 65535 seconds. The suggested value: 30 seconds.
bgpPeerInUpdateElapsedTime	Elapsed time in seconds since the last BGP UPDATE message was received from the peer. Each time *bgpPeerInUpdates* is incremented the value of this object is set to zero (0).

BGP-4 Received Path Attribute Table

Table B-17 BGP-4 Received Path Attribute Table

Field	Description
bgp4PathAttrPeer	The IP address of the peer where the path information was learned.
bgp4PathAttrIpAddrPrefixLen	Length in bits of the IP address prefix in the Network Layer Reachability Information field.
bgp4PathAttrIpAddrPrefix	An IP address prefix in the Network Layer Reachability Information field. This object is an IP address containing the prefix with length specified by *bgp4PathAttrIpAddrPrefixLen*. Any bits beyond the length specified by *bgp4PathAttrIpAddrPrefixLen* are zeroed.
bgp4PathAttrOrigin	The ultimate origin of the path information: igp(1), interior networks, egp(2), networks learned via EGP, incomplete(3), undetermined.

Table B-17 BGP-4 Received Path Attribute Table (continued)

Field	Description
bgp4PathAttrASPathSegment	The sequence of AS path segments. Each AS path segment is represented by a triple <type, length, value>. The type is a 1-octet field which has two possible values: • AS_SET: unordered set of ASs a route in the UPDATE messages has traversed. • AS_SEQUENCE: ordered set of ASs a route in the UPDATE messages has traversed. The length is a 1-octet field containing the number of ASs in the value field. The value field contains one or more AS numbers. Each AS is represented in the octet string as a pair of octets according to the following algorithm: • first-byte-of-pair = ASNumber / 256; • second-byte-of-pair = ASNumber & 255;
bgp4PathAttrNextHop	The address of the border router that should be used for the destination network.
bgp4PathAttrMultiExitDisc	This metric discriminates between multiple exit points to an adjacent AS, ranging from 1 to 2147483647. A value of -1 indicates the absence of this attribute.
bgp4PathAttrLocalPref	The originating BGP4 speaker's degree of preference for an advertised route, ranging from 1 to 2147483647. A value of -1 indicates the absence of this attribute.
bgp4PathAttrAtomicAggregate	Whether or not the local system has selected a less specific route without selecting a more specific route.
bgp4PathAttrAggregatorAS	The AS number of the last BGP4 speaker that performed route aggregation, ranging from 0 -65535. A value of zero (0) indicates the absence of this attribute.
bgp4PathAttrAggregatorAddr	The IP address of the last BGP4 speaker that performed route aggregation. A value of 0.0.0.0 indicates the absence of this attribute.
bgp4PathAttrCalcLocalPref	The degree of preference calculated by the receiving BGP4 speaker for an advertised route, ranging from 1 to 2147483647. A value of -1 indicates the absence of this attribute.
bgp4PathAttrBest	An indication of whether or not this route was chosen as the BGP4 route.
bgp4PathAttrUnknown	One or more path attributes not understood by this BGP4 speaker. Range: 0-255. Size zero (0) indicates the absence of such attribute(s). Octets beyond the maximum size, if any, are not recorded by this object.

BGP-4 Traps

Table B-18 BGP-4 Traps

Field	Description
bgpEstablished	The BGP Established event is generated when the BGP FSM enters the ESTABLISHED state.
bgpBackwardTransition	The *BGPBackwardTransition* Event is generated when the BGP FSM moves from a higher numbered state to a lower number state.

Firewall MIB Tables

The firewall MIB contains the following tables, most of which are detailed in this section: Firewall on Interface Group, Interface to Policy Group, Group Policy, Policy Rule Definition, Authentication Group, Network in Network Group, Network Group, Network, Compound Filter, Sub Filter, IP Header Filter, Offset Filter, IP Options Header Filter, Data Filter, Policy Rule True, Session Totals, IP Session, Auth Address Group, and DOS Blocked Group.

Global Interface Operations

Some configurable items affect all interfaces on the XSR. For each of these operations, a pointer is created to the firewall configuration object when the SNMP/FW command dispatcher determines the type of operation. This object maintains the current state of each of the global interface operations.

Note: The XSR supports only SNMP gets for these objects.

The following objects take immediate action on the firewall engine.

Table B-19 Configuration Objects

Field	Description
etsysFWFirewallEnabled	The current state of the firewall is returned when this value is read. The value read may be different than the last value set if the state is changed by a means other than this MIB. This is a read-write field. Setting the value to true causes the firewall to start inspecting packets while setting it to false causes the firewall to stop inspecting packets.
etsysFWTcpTimeout	The current value of the TCP timer (for all interfaces) is returned from the firewall configuration object on read. During a set operation, the value of the TCP timer (for all interfaces) is updated in the firewall configuration object.
etsysFWUdpTimeout	The current value of the UDP timer (for all interfaces) is returned from the firewall configuration object on read. During a set operation, the value of the UDP timer (for all interfaces) is updated in the firewall configuration object.
etsysFWIcmpTimeout	The current value of the ICMP timer (for all interfaces) is returned from the firewall configuration object on read. During a set operation, the value of the ICMP timer (for all interfaces) is updated in the firewall configuration object.
etsysFWAuthTimeout	The current value of the Auth timer (for all interfaces) is returned from the firewall configuration object on read. During a set operation, the value of the Auth timer (for all interfaces) is updated in the firewall configuration object.
etsysFWAuthPort	The current value of the Auth Port (for all interfaces) is returned from the firewall configuration object on read. During a set operation, the value of the Auth Port (for all interfaces) is updated in the firewall configuration object.
etsysFWLoggingThreshold	The current value of the Logging Threshold (for all interfaces) is returned from the firewall configuration object on read. During a set operation, the value of the Logging Threshold (for all interfaces) is updated in the firewall configuration object. There are eight event levels in the firewall and four on the XSR. Levels 0-3 constitute the *High* XSR logging threshold, Levels 4 and 5 are *Medium*, Level 6 is *Low* and Level 7 is *Debug*.

Monitoring Objects

This section describes counters and statistics that are available to SNMP from the firewall. All fields are read-only and cannot be modified. The XSR supports *SNMP gets* only for these objects.

Policy Rule Table Totals Counters

These counters track the number of policy hit totals.

Table B-20 Policy Rule Table Totals

Field	Description
etsysFWPolicyRuleTrueNumEntries	The current number of entries in the policy rule true table.
etsysFWPolicyRuleTrueLastChange	The date and time when the policy rule true table was last modified.

Policy Rule True Table

These counters track the number of policy hits per policy.

Table B-21 Policy Rule True Table

Field	Description
etsysFWPolicyRuleTrueEvents	The number of times this policy rule evaluated to true since the the last XSR restart.
etsysFWPolicyRuleTrueLastEvent	The date and time when the rule was last true.

Session Totals Counters

Session totals contain summary data about the status of sessions contained in the session totals table.

Table B-22 Session Totals

Field	Description
etsysFWSessionTotalsNumEntries	The current number of entries in the IP session totals table.
etsysFWSessionTotalsLastChange	The system time when the last change was made to the session totals table.

Session Totals Table

Table B-23 Session Totals Table

Field	Description
etsysFWSessTotProtocolId	Protocol-ID for this row.
etsysFWSessTotActiveSessions	The total number of active sessions for this protocol.
etsysFWSessTotPeakSessions	The peak number of session for this protocol since the last restart of the XSR.
etsysFWSessTotBlockedSessions	The sum of sessions that have been blocked since the last restart of the XSR.
etsysFWSessTotLastBlock	The date and time of the last blocked session for this protocol.

IP Session Counters

These counters track the activities of IP sessions.

Table B-24 IP Sessions

Field	Description
etsysFWIpSessionNumEntries	The number of entries in the IP session table.
etsysFWIpSessionLastChange	The date and time of the last change to the IP session table.

IP Session Table

This table contains information about each active IP session.

Table B-25 IP Session Table

Field	Description
etsysFWIpSessionIndex	The unique index number for this row.
etsysFWIpSessionIPVersion	The Internet protocol version that indicates the size and format of the source address and destination address objects.
etsysFWIpSessionSrcAddress	The source IP address of this session.
etsysFWIpSessionDstAddress	The destination IP address of this session.
etsysFWIpSessionSrcPort	The source port number for this session.
etsysFWIpSessionDstPort	The destination port number for this session.
etsysFWIpSessionProtocolID	The protocol ID of this session as defined by the IANA.
etsysFWIpSessionCreation	The date and time this session was created.

Authenticated Address Counters

This table provides a summary of the authentication activity.

Table B-26 Authenticated Addresses

Field	Description
etsysFWAuthAddressNumEntries	The total number of entries in the authenticated address table.
etsysFWAuthAddressLastChange	The date and time of the last change in the authenticated address table.

Authenticated Addresses Table

This table provides detailed information about each authenticated address.

Table B-27 Authenticated Addresses Table

Field	Description
etsysFWAuthAddressIndex	The unique index of this row.

Table B-27 Authenticated Addresses Table (continued)

Field	Description
etsysFWAuthAddressIPVersion	This entry's IP version number which determines the size and format of the IP Address object.
etsysFWAuthAddressIPAddress	The authenticated IP address.
etsysFWAuthAddressGroupName	The authentication group name to which this authenticated address entry belongs.
etsysFWAuthAddressIdleTime	The interval in seconds that this address has been idle.

DOS Attacks Blocked Counters

These elements reflect the DOS attack summaries stored in the firewall.

Table B-28 DOS Attacks Blocked

Field	Description
etsysFWDoSBlockedNumEntries	The current total number of entries in the DOS attacks blocked table.
etsysFWDoSBlockedLastChange	The date and time of the last change to the DOS attacks blocked table.

DOS Attacks Blocked Table

These elements reflect the hits against DOS attack types recognized by the firewall.

Table B-29 DOS Attacks Blocked Table

Field	Description
etsysFWDoSAttackName	The name of this kind of DOS attack.
etsysFWDoSSrcIPVersion	The IP version, it determines the size and format of the IP address object.
etsysFWDoSSrcIPAddress	The IP address on which this attack was last blocked.
etsysFWDoSAttackTime	The date and time of the last blocked attack.
etsysFWDoSBlockedAttacks	The sum of times this DOS attack has been blocked since the last restart of the XSR.

VPN MIB Tables

The XSR supports the following VPN tables, whose fields are described in the following pages:

- *etsysVpnIkePeerTable*
- *etsysVpnIkePeerProposalsTable*
- *etsysVpnIkeProposalTable*
- *etsysVpnIpsecPolicyTable*
- *etsysVpnIntfPolicyTable*
- *etsysVpnIpsecPolicyRuleTable*
- *etsysVpnIpsecPolProposalsTable*

- *etsysVpnIpsecProposalTable*
- *etsysVpnIpsecPropTransformsTable*
- *etsysVpnAhTransformTable*
- *etsysVpnEspTransformTable*
- *etsysVpnIpcompTransformTable*
- *ospfIfTable*
- *rip2IfConfTable*
- *ipCidrRouteTable for Static Routes*

etsysVpnIkePeer Table

This table is used to configure an IKE peer and the associated parameters of that peer. The table index is {*etsysVpnIkePeerAddrType*, *etsyVpnIkePeerAddress*}.

Table B-30 etsysVpnIkePeerTable

Field	Description
etsysVpnIkePeerAddrType	This InetAddressType object is required for future compatibility with IPv6. For the XSR, this can currently be set to IPv4 only.
etsysVpnIkePeerAddress	Since address type is IPv4, this is always a 4-octet IP address.
etsysVpnIkePeerAddrMask	Since address type is IPv4, this is always a 4-octet IP address mask.
etsysVpnIkePeerExchangeMode	Acceptable values are mainMode(2) and aggressive(4). When used to create a row, all other values are defaulted.
etsysVpnIkePeerConfigMode	When used to create a row, all other values are defaulted.
etsysVpnIkePeerNatTraversal	When used to create a row, all other values are defaulted.
etsysVpnIkePeerIdentity	When used to create a row, all other values are defaulted.
etsysVpnIkePeerRowStatus	Acceptable values are active(1), createAndGo(4) and destroy(6). When used to create a row, all values are defaulted.

etsysVpnIkePeerProposals Table

This table links IKE proposals in the *etsysVpnIkeProposalTable* with IKE peers in the *etsysVpnIkePeerTable*. The XSR implementation permits a maximum of three proposals and priority values 1, 2, or 3 only. Be aware that the lower priority row must exist before a higher priority proposal can be created, that is, if no priority row equals 1, then priority rows 2 and 3 cannot be created. Also, a proposal in the *etsysVpnIkeProposalTable* must exist before the corresponding row can be created in this table. The table index is {*etsysVpnIkePeerAddrType*, *etsysVpnIkePeerAddress*, *etsysVpnIkePeerPropPriority*}.

Table B-31 etsysVpnIkePeerProposalsTable

Field	Description
etsysVpnIkePeerPropPriority	An index value for the proposal.

Table B-31 etsysVpnIkePeerProposalsTable (continued)

Field	Description
etsysVpnIkePeerPropName	A proposal name from the etsysVpnIkeProposalTable. This object must be used to create the row.
etsysVpnIkePeerPropRowStatus	Acceptable values: active(1) and destroy(6). You cannot use this object to create a row since the proposal name is needed first.

etsysVpnIkeProposal Table

This table contains the IKE proposals used during IKE negotiation. The named row is equivalent to the **`crypto isakmp proposal`** CLI command. The table index is {*etsysVpnIkePropName*}, which is the name referenced in the *etsysVpnIkePeerProposalsTable*.

Table B-32 etsysVpnIkeProposalTable

Field	Description
etsysVpnIkePropName	The index of the table.
etsysVpnIkePropEncryptAlgorithm	Acceptable values are desCbc(1), tripleDesCbc(5), and aesCbc(7). When used to create a row, all other values are defaulted.
etsysVpnIkePropHashAlgorithm	Acceptable values are md5(1) and sha(2). When used to create a row, all other values are defaulted.
etsysVpnIkePropDhGroup	Acceptable values: modp768(1), modp1024(2) and modp1536(5). When used to create a row, all other values are defaulted.
etsysVpnIkePropAuthMethod	Acceptable values are preSharedKey(1) and rsaSignatures(3). When used to create a row, all other values are defaulted.
etsysVpnIkePropMaxLifetimeSecs	Acceptable values are 300-8640000. Default value is 28800. When used to create a row all other values are defaulted.
etsysVpnIkePropMaxLifetimeKB	Since the CLI does not allow this to be set, the XSR will implement this as read-only.
etsysVpnIkePropRowStatus	Acceptable values are active(1), createAndGo(4) and destroy(6). When used to create a row, all values are defaulted.

etsysVpnIpsecPolicy Table

This read-only table lists the IPSec policy names on the XSR. This table includes those policies configured by means other than this MIB or CLI (that is, EZ-IPSec). The table index is {*etsysVpnIpsecPolicyName*}. These policy names are used as values for *etsysVpnIntfPolicyName* when applying policy to an interface.

Table B-33 etsysVpnIpsecPolicyTable

Field	Description
etsysVpnIpsecPolicyName	The name of an IPSec policy.

etsysVpnIntfPolicy Table

This table applies IPSec policy to an interface. The table index is {ifIndex} from the mib-2 *ifTable*.

Table B-34 etsysVpnIntfPolicyTable

Field	Description
etsysVpnIntfPolicyName	The name of an IPSec policy. When used to create a row, all other values are defaulted.
etsysVpnIntfPolicyDFHandling	When used to create a row, all other values are defaulted.
etsysVpnIntfPolicyRowStatus	Acceptable values are active(1) and destroy(6).

etsysVpnIpsecPolicyRule Table

This table defines the IPSec policy rules. The table index is {*etsysVpnIpsecPolicyName*, *etsysVpnPolRulePriority*}.

Table B-35 etsysVpnIpsecPolicyRuleTable

Field	Description
etsysVpnIpsecPolRulePriority	The priority of the rule, equivalent to the sequence number from the CLI commands.
etsysVpnIpsecPolRulePeerAddrType	This InetAddressType object is required for future compatibility with IPv6. For the XSR, this can only be set to IPv4. When used to create a row, all other values are defaulted.
etsysVpnIpsecPolRulePeerAddress	Since the address type is IPv4, this is always a 4-octet IP address. When used to create a row, all other values are defaulted.
etsysVpnIpsecPolRuleCommonSA	When used to create a row, all other values are defaulted.
etsysVpnIpsecPolRuleMode	Acceptable values: tunnel(1) and transport(2). When used to create a row, all other values are defaulted.
etsysVpnIpsecPolRuleSelectorId	On the XSR, this is an ASCII string representing an access group, e.g. *100*. When used to create a row, all other values are defaulted.
etsysVpnIpsecPolRuleRowStatus	Acceptable values: active(1), createAndGo(4) and destroy(6). When used to create a row, all values are defaulted.

etsysVpnIpsecPolProposals Table

This table links IPSec proposals in the *etsysVpnIpsecProposalTable* with IPSec policy rules in the *etsysVpnIpsecPolRuleTable*. The XSR implementation permits a maximum of six proposals and priority values 1, 2, 3, 4, 5, or 6 only. Be aware that the lower priority row *must* exist before a higher priority proposal can be created; that is, if no priority row equals 1, then priority rows 2 through 6 cannot be created. Also, be advised that a proposal in the *etsysVpnIpsecProposalTable* must exist *before* the corresponding row can be created in this table. The table index is {*etsysVpnIpsecPolicyName*, *etsysVpnIpsecPolRulePriority*, *etsysVpnIpsecPolPropPriority*}.

Table B-36 etsysVpnIpsecPolProposalsTable

Field	Description
etsysVpnIpsecPolPropPriority	An index value for the proposal.
etsysVpnIpsecPolPropProposalName	A proposal name from the *etsysVpnIpsecProposalTable*. This object must be used to create the row.
etsysVpnIpsecPolPropRowStatus	Acceptable values: active(1) and destroy(6). This object cannot be used to create a row since the proposal name is needed first.

etsysVpnIpsecProposal Table

This table contains the IPSec proposals. The table index is {*etsysVpnIpsecPropName*}.

Table B-37 etsysVpnIpsecProposalTable

Field	Description
etsysVpnIpsecPropName	The name of an IPSec proposal.
etsysVpnIpsecPropMaxLifetimeSec	Acceptable values are 300-8640000 seconds with a default of 28800. When used to create a row, all other values are defaulted.
etsysVpnIpsecPropMaxLifetimeKB	Since the CLI does not allow this to be set, the XSR implements this as read-only.
etsysVpnIpsecPropUsePfs	
etsysVpnIpsecPropGroupId	
etsysVpnIpsecPropRowStatus	Acceptable values are active(1), createAndGo(4) and destroy(6). When used to create a row, all values are defaulted.

etsysVpnIpsecPropTransforms Table

This table aggregates transforms from the *ipspAhTransformTable, ipspEspTransformTable,* and *ipspIpcompTransformTable* into transform sets. The table index is {*etsysVpnIpsecPropName, etsysVpnIpsecPropTranType*}. The table also contains read-only rows for XSR EZ-IPSec transforms.

Table B-38 etsysVpnIpsecPropTransformsTable

Field	Description
etsysVpnIpsecPropTranType	Acceptable values: protoIpsecAh(2) and protoIpsecEsp(3). Since the XSR does not support software compression, protoIpcomp(4) is unavailable.
etsysVpnIpsecPropTranName	A transform name. This object must be used to create the row. The corresponding row in the AH or ESP transform table will be created when this row is created. The transform will have default values.
etsysVpnIpsecPropTranRowStatus	Acceptable values: active(1) and destroy(6). This object cannot be used to create a row since the transform name is needed first.

etsysVpnAhTransform Table

This table lists all the AH transforms created by adding AH rows to the *etsysVpnIpsecPropTransformsTable*. The table also contains read-only rows for XSR EZ-IPSec transforms. The table index is {*etsysVpnAhTranName*}.

Table B-39 etsysVpnAhTransformTable

Field	Description
etsysVpnAhTranName	The name of an AH transform.
etsysVpnAhTranAlgorithm	Acceptable values: hmacMd5(1) and hmacSha(2). This value can be set after the row is created via the creation of a row in the *etsysVpnIpsecPropTransformsTable*.
etsysVpnAhTranMaxLifetimeSec	This is read-only for the XSR since *etsysIpsecPropLifetimeSec* is used as a common setting for the proposal.

Table B-39 etsysVpnAhTransformTable (continued)

Field	Description
etsysVpnAhTranMaxLifetimeKB	This is read-only for the XSR.
etsysVpnAhTranRowStatus	Always equal to active(1). The transform is destroyed by destroying the corresponding row in the *etsysVpnIpsecPropTransformsTable*.

etsysVpnEspTransform Table

This table lists all the ESP transforms created by adding ESP rows to the *etsysVpnIpsecPropTransformsTable*. The table also contains read-only rows for XSR EZ-IPSec transforms. The table index is {*etsysVpnEspTranName*}.

Table B-40 etsysVpnEspTransformTable

Field	Description
etsysVpnEspTranName	The name of an ESP transform.
etsysVpnEspTranCipherTransformId	Acceptable values: espDes(2), esp3Des(3) and espAes(12) which can be set after the row is created via the creation of a row in the *etsysVpnIpsecPropTransformsTable*.
etsysVpnEspTranCipherKeyLength	A read-only value for the XSR.
etsysVpnEspTranCipherRounds	A read-only value for the XSR.
etsysVpnEspTranMaxLifetimeSec	This is read-only for the XSR since *etsysIpsecPropLifetimeSec* is used as a common setting for the proposal.
etsysVpnEspTranMaxLifetimeKB	This is read-only for the XSR.
etsysVpnEspTranRowStatus	Always equal to active(1). The transform is destroyed by removing the corresponding row in the *etsysVpnIpsecPropTransformsTable*.

etsysVpnIpcompTransform Table

Only hardware compression is available. This table will always be empty.

ipCidrRouteTable for Static Routes

VPN configuration on the XSR may require a default route to the next-hop Internet gateway. Static routes can be added with the IP Forwarding MIB (RFC-2096). This MIB is not currently implemented on the XSR, although it is one the core recommended MIBs for all Enterasys devices. The MIB updates and obsoletes the MIB-II *ipRouteTable*. Static routes will be added in the IP Forwarding MIB *ipCidrRouteTable*. The table indices are comprised of the route destination address, mask, TOS, and next hop address. The following objects from the table can be used to create a static route:

Table B-41 ipCidrRouteTable

Field	Description
ipCidrRouteDest	Sets the IP address for the destination network. This read-only value is defined as part of the index when the row is created.
ipCidrRouteMask	Sets the IP mask for the destination network specified in *ipCidrRouteDest*. This read-only value is defined as part of the index when the row is created.
ipCidrRouteTos	Sets the TOS for the route. This read-only value is set as part of the index when the row is created.
ipCidrRouteNextHop	Sets the IP address of the next hop for this route. This read-only value is set as part of the index when the row is created.
ipCidrRouteIfIndex	Sets the ifIndex value for the local interface through which the next hop should be reached.
ipCidrRouteType	Sets the type of route including local (3) or remote (4).
ipCidrRouteMetric1	Sets the routing metric for this route. The XSR accepts values of 1-120 as the distance metric.
ipCidrRouteStatus	Sets the RowStatus value for this row according to textual convention including: *active (1), createAndWait (5),* or *destroy (6)*. The XSR reports values of *active (1) and notReady (3).*

Host Resources MIB Objects

The XSR supports the following table objects in the Host Resources MIB, defined in RFC-2790.

Table B-42 Host Resources MIB Objects

Field	Description
hrMemorySize	The amount of physical read-write main memory - RAM - contained in the host.
hrStorageTable	An entry for system RAM. This is a useful diagnostic for *out of memory* and *out of buffers* failures. Also, it can be a performance monitoring tool for tracking memory, disk, or buffer usage.
hrDeviceTable	An entry for the processors. This object is enabled via the CLI **`cpu utilization`** command.
hrProcessorTable	An entry for the processors to report load. This object is enabled via the CLI cpu utilization command.

Enterasys Configuration Management MIB

The Enterasys Configuration Management MIB supports parameters for an SNMP management entity to reset the managed entity, upload and download executable images and configuration files, and identify the active executable image and configuration files. Be aware that only one operation can be specified at a time. Refer to the supported fields in the following table.

Table B-43 etsysConfigurationManagement

Field	Description
ConfigMgmtOperations	
resetHardware(0)	Initiates a hardware reset.
resetSoftware(1)	Initiates a software reset.
imageDownload(2)	Initiates an image download using the least disruptive method available to it given the specified protocol. The downloaded image is stored in persistent storage.
configurationUpload(5)	Transfers the currently active configuration to the specified destination.
configurationDownload(6)	Initiates a configuration file download using the least disruptive method available to it given the specified protocol. The downloaded configuration is stored in persistent storage.
imageGetSelected(8)	The file selected as the boot image is returned in *etsysConfigMgmtChangeURL*.
Configuration Management Status Group	
etsysConfigMgmtCurrentImageURL	The URL of the last image successfully loaded into memory.
etsysConfigMgmtCurrentConfigURL	The URL of the last configuration file successfully loaded into memory.
etsysConfigMgmtPersistentStorageStatus	The status of any current failures of any of the persistent storage facilities.
Configuration Management Change Group	
etsysConfigMgmtChangeLimit	The maximum number of configuration change requests the XSR can hold in the *etsysConfigMgmtChangeTable*.
etsysConfigMgmtChangeCurrent	Sum of configuration change requests currently in the *etsysConfigMgmtChangeTable*.
etsysConfigMgmtChangeCompleted	Sum of configuration change requests that have completed successfully or otherwise. This object should be stored in persistent memory.
etsysConfigMgmtChangeSupportedURLs	*etsysConfigMgmtTftp(3)* - The URLs the XSR supports for transferring files. These define the transfer protocols and remote file names.
etsysConfigMgmtChangeSupportedOperations	Configuration change operations supported on the XSR: *etsysConfigMgmtChangeOperation* and *resetHardware (0), resetSoftware (1) , imageDownload (2), configurationReset (4), configurationUpload (5), configurationDownload (6), imageGetSelected (8),* and *configurationAppend (10)* [The configuration file specified in the *etsysConfigMgmtChangeURL* is applied to the active configuration and becomes the running configuration. If the entity does not support the *configurationPersist* operation the result also becomes the start-up configuration.

Table B-43 etsysConfigurationManagement (continued)

Field	Description
etsysConfigMgmtChangeNextAvailableIndex	The numerically lowest available index within the XSR, which may be used for the value of *etsysConfigMgmtChangeIndex* in the creation of a new entry in the *etsysConfigMgmtChangeTable*.
sysConfigMgmtPersistentStorageChSum	The MD5 message digest of the content of the following files will be stored in this field: *startup-config, private-config, user.dat*. Initially when the device comes up we calculate the MD5 message digest for those files and store them in this field, then this field get updated upon any changes to the content of those files.

Enterasys Configuration Change MIB

The Enterasys Configuration Change MIB supports parameters for SNMP management entities to determine if and when configuration changes have occurred. Refer to the supported fields in the following table.

Table B-44 etsysConfigurationChange MIB

Field	Description
etsysConfigChangeNonVolatile Group	
etsysConfigChangeNonVolatileCount	The number of successful non-volatile, or persistent configuration changes.
etsysConfigChangeNonVolatileTime	The date and time of the last successful non-volatile, or persistent, configuration change.
etsysConfigChangeNonVolatileMethod	The method used to make the last non-volatile change. That is, SNMP, TELNET, and CLI. If the individual user login or source IP address is available, they should be included in this string. Example format: **<TELNET: 192.168.0.1: JohnJones>**
etsysConfigChangeVolatile Group	
etsysConfigChangeVolatileCount	Sum of successful volatile, or non-persistent, configuration changes.
etsysConfigChangeVolatileTime	The date and time of the last successful volatile, or non-persistent, configuration change.
etsysConfigChangeVolatileMethod	The method used to make the last volatile change. i.e.: SNMP, TELNET, LM, CLI. If the individual user login, or source IP address, is available they should be included in this string. Example format: **<TELNET: 192.168.0.1: JohnJones>**
etsysConfigChangeFirmware Group	
etsysConfigChangeFirmwareCount	The number of successful firmware image downloads: *etsysConfigChangeFirmware 1*
etsysConfigChangeFirmwareTime	The date and time of the last successful firmware image download.
etsysConfigChangeFirmwareMethod	The method that was used to cause the last firmware change. i.e. SNMP, TELNET, LM, CLI. If the individual user login, or the source IP address, is available they are included in this string. example format: **<TELNET: 192.168.0.1: JohnJones>**
Conformance Information	
etsysConfigChangeNonVolatileGroup	A collection of objects providing non-volatile configuration change data.
etsysConfigChangeVolatileGroup	A collection of objects providing volatile configuration change data.

Table B-44 etsysConfigurationChange MIB (continued)

Field	Description
etsysConfigChangeFirmwareGroup	A collection of objects providing firmware change data.
etsysConfigChangeCompliance	The compliance statement for configurable devices.

Enterasys SNMP Persistence MIB

This MIB permits management applications to commit persistent SNMP configuration information to persistent storage.

Table B-45 etsysSnmpPersistenceMIB

Field	Description
etsysSnmpPersistenceMode	Setting this object to *snmpNormalSave(1)* will cause the XSR to exhibit what could be considered normal SNMP behavior, that is, each SNMP set of a persistent object will be saved to persistent storage as part of the set operation. • Setting this object to *pushButtonSave(2)* will cause SNMP sets of persistent objects to be buffered in volatile memory until the configuration is explicitly saved to persistent memory, either through the CLI or by setting *etsysSnmpPersistenceWrite* to *save(2)*. • Setting this object to *timeDelayedSave(3)* will cause SNMP sets of persistent objects to be buffered in volatile memory until certain implementation dependent time conditions are met. Once these conditions are met the configuration is saved to persistent memory. • Setting this object to a mode that is not supported on that particular implementation leads to an inconsistent value error. • On an SNMP get operation this object will return the current persistent storage mode of operation.
etsysSnmpPersistenceSave	Setting this object to save(2) will cause the current configuration stored in volatile memory to be written to persistent memory and become the start-up configuration. • This also causes any configuration data that is part of another management interface's active configuration to become part of the start-up configuration. • Any configuration changes made through SNMP will become part of the start-up configuration if and when another management interface saves the current configuration to persistent storage. • Setting this object to *save(2)* while the value of the *etsysSnmpPersistenceMode* object is NOT *pushButtonSave(2)* MAY lead to an inconsistent value error. • Setting this object to *save(2)* while the value of the *etsysSnmpPersistenceStatus* object is *savingChanges(3)* leads to an inconsistent value error. • Setting this object to *nop(1)* always succeeds and has no effect. • On an SNMP get operation this object will return *nop(1)*. • Management applications are advised to make use of the *snmpSetSerialNo* object defined in the SNMPv2-MIB to coordinate their use of this object.
etsysSnmpPersistenceStatus	Current status of the persistent storage system when *etsysSnmpPersistenceMode* is NOT set to *snmpNormalSave(1)*. Status states include: *other, unsavedChanges, savingChanges, saveSucceeded, saveFailed.*
etsysSnmpPersistenceStatusTime	Value of *sysUpTime* when *etsysSnmpPersistenceStatus* was last updated. If *etsysSnmpPersistenceStatus* was not updated since initialization, zero is returned.
etsysSnmpPersistenceError	A descriptive error message if the last attempt to write to persistent storage has failed.
etsysSnmpPersistenceErrorTime	The data and time when the *etsysSnmpPersistenceError* was last updated. If *etsysSnmpPersistenceError* has not been updated since initialization the value '0000000000000000'H is returned.

Table B-45 etsysSnmpPersistenceMIB (continued)

Field	Description
etsysSnmpPersistenceGroup	A collection of objects providing support for delayed persistence of otherwise persistent SNMP objects.
etsysSnmpPersistenceCompliance	The compliance statement for devices that support delayed persistence of otherwise persistent SNMP objects.

Enterasys Syslog Client MIB

This Enterasys MIB module defines a portion of the SNMP Enterprise MIBs under the Enterasys Enterprise OID pertaining toconfiguriation of Syslog-compatible diagnostic messages generated for the XSR.

Table B-46 Enterasys Syslog Client MIB

Field	Description
etsysSyslogClient Group	
etsysSyslogClientMessages	The number of messages successfully delivered to the upstream side of the syslog client software for processing.
etsysSyslogClientMessagesDropped	The number of messages unable to be queued to the downstream side of the syslog client software for transmitting.
etsysSyslogClientLastMessageTime	The *sysUpTime* of the last attempt, successful or otherwise, to queue a message to the downstream side of the syslog client software.
etsysSyslogClientControl	A list of attributes to control the operation of the syslog client: *etsysSyslogClientControlConsoleLogging(0)* - Log messages to console. *etsysSyslogClientControlPersistentLogging(1)* - Log messages to non-volatile store.
etsysSyslogServer Table Group	
etsysSyslogServerMaxEntries	The maximum number of entries allowed in the *etsysSyslogServerTable*.
etsysSyslogServerNumEntries	The number of entries currently in the *etsysSyslogServerTable*.
etsysSyslogServerTableNextAvailableIndex	The numerically lowest available index within this entity, which may be used for the value of *etsysSyslogServerIndex* in creating a new entry in the *etsysSyslogServerTable*. An index is considered available if the index value ranges from 1 to 8 and is not being used to index an existing entry in the *etsysSyslogServerTable* contained within this entity. A value of zero indicates that all entries in the *etsysSyslogServerTable* are currently in use. This value should only be considered a guideline for management creation of *etsysSyslogServerEntries;* there is no requirement on management to create entries based upon this index value.
etsysSyslogServer Table	
etsysSyslogServerEntry:	Defines data to generate syslog messages to an aggregating agent or server. Table entries with an access level of read-create MUST be considered non-volatile and MUST be maintained across entity resets.
• *etsysSyslogServerIndex*	A unique arbitrary identifier for this syslog server.
• *etsysSyslogServerDescription*	Administratively assigned textual description of this syslog server.

Table B-46 Enterasys Syslog Client MIB (continued)

Field	Description
• *etsysSyslogServerAddressType*	The type of Internet address by which the Syslog server is specified in *etsysSyslogServerAddress*.
• *etsysSyslogServerAddress*	The Internet address for the Syslog message server.
• *etsysSyslogServerUdpPort*	The UDP port number the client is using to send requests to this server.
• *etsysSyslogServerFacility*	Syslog facility (local0-local7) to be encoded in messages sent to this server.
• *etsysSyslogServerSeverity*	Maximum severity level of messages that should be forwarded to the syslog server. The higher the level, the lower the severity.
• *etsysSyslogServerMessagesIgnored*	A count of messages not sent to this server because the severity level of the message was above *etsysSyslogServerSeverity;* the higher the level, the lower the severity.
• *etsysSyslogServerRowStatus*	Allows for the dynamic creation and deletion of entries within the *etsysSyslogServerTable* as well as activation/deactivation of these entries. When this object's value is set to *notInService(2)* this server will not be sent any messages, nor will any of its counters be incremented.
Syslog Server Defaults	
etsysSyslogServerDefaultUdpPort	Default UDP port number that the managed entity uses to send syslog messages. This value will be used as the default value for *etsysSyslogServerUdpPort* when creating rows in the *etsysSyslogServerTable* and either: • no value is specified for *etsysSyslogServerUdpPort*, or • *etsysSyslogServerUdpPort* is implemented read-only.
etsysSyslogServerDefaultFacility	The default syslog facility (local0-local7) to be encoded in syslog messages. This value will be used as the default value for *etsysSyslogServerFacility* when creating rows in the *etsysSyslogServerTable* and either: • no value is specified for *etsysSyslogServerFacility*, or • *etsysSyslogServerFacility* is implemented read-only.
etsysSyslogServerDefaultSeverity	Default syslog message severity level used to filter all syslog messages. This value will be used as the default value for *etsysSyslogServerSeverity* when creating rows in the *etsysSyslogServerTable* and either: • no value is specified for *etsysSyslogServerSeverity*, or • *etsysSyslogServerSeverity* is implemented read-only. The higher the severity level, the less critical it is.
Units of Conformance	
etsysSyslogClientGroup	A collection of objects providing syslog message statistics: • *etsysSyslogClientMessages* • *etsysSyslogClientMessagesDropped* • *etsysSyslogClientLastMessageTime* • *etsysSyslogClientControl*

Table B-46 Enterasys Syslog Client MIB (continued)

Field	Description
etsysSyslogServerGroup	A collection of objects providing descriptions of syslog servers for sending system messages to: • *estetsysSyslogServerMaxEntries* • *etsysSyslogServerNumEntries* • *etsysSyslogServerTableNextAvailableIndex* • *etsysSyslogServerDescription* • *etsysSyslogServerAddressType* • *etsysSyslogServerAddress* • *etsysSyslogServerUdpPort* • *etsysSyslogServerFacility* • *etsysSyslogServerSeverity* • *etsysSyslogServerMessagesIgnored* • *etsysSyslogServerRowStatus*
etsysSyslogServerDefaultsGroup	A collection of objects providing default values for the syslog servers that can optionally be overridden on a per server basis with *etsysSyslogServerFacility*, *etsysSyslogServerSeverity*, or *etsysSyslogServerUdpPort*.
Compliance Statements	
etsysSyslogClientCompliance	The compliance statement for devices that support sending system messages to a syslog server.
etsysSyslogClientControl	Write access is not required for implementations that do not support configuring BOTH console AND persistent logging. Implementations may choose to support only a subset of the client controls. Sets which attempt to modify unsupported controls should fail.
etsysSyslogServerUdpPort	Write access is not required for implementations that do not support configuring the UDP port number on a per server basis.
etsysSyslogServerFacility	Write access is not required for implementations that do not support configuring the syslog facility on a per server basis.
etsysSyslogServerSeverity	Write access is not required for implementations that do not support configuring the message severity level on a per server basis.
etsysSyslogServerDefaultUdpPort	Write access is not required for implementations that do not support configuring the UDP port number at all, or do not want to support a configurable default.
etsysSyslogServerDefaultFacility	Write access is not required for implementations that do not support configuring the syslog facility at all, or do not want to support a configurable default.
etsysSyslogServerDefaultSeverity	Write access is not required for implementations that do not support configuring the syslog facility at all, or do not want to support a configurable default.
etsysSyslogApplicationAllowedServers	Write access is not required for implementations that do not support configuring the syslog facility at all, or do not support specification of allowable servers per application.